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Hydrogeological Report
Lajes Field,
Azores, Portugal
FINAL

Contract No. F41624-03-D-8595
Task Order 0085
Project Number MNQA 02-6009

February 2005

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Contract F41624-03-D-8595, Task Order 0085,
Project Number MNQA 02-6009

Dear Mr. Hansen:

CH2M HILL is pleased to submit the Final Hydrogeological Study Report for Lajes Field, Azores, Portugal. It was prepared in accordance with CDRL A001A and A001B under Contract F41624-03-D-8595, Task Order 0085. All received comments from Lajes Field CEV and AFCEE have been wisely reviewed and implemented whenever appropriate. A copy is also supplied to Lajes Field/CEV and HQ USAFE/CEV.

We appreciate the opportunity to perform these services for AFCEE and USAFE. If you have any comments or questions concerning this document, or if there is anything CH2M HILL International can do to assist AFCEE or USAFE, please call me at 011-49-631-892-9877.

Yours sincerely,

CH2M HILL

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HYDROGEOLOGICAL STUDY REPORT LAJES FIELD, AZORES, PORTUGAL

FINAL

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Task Order 0085
Project Number MNQA 02-6009

February 2005

Executive Summary

CH2M HILL was contracted by the Air Force Center for Environmental Excellence, at the request of the United States Air Forces in Europe (USAFE), to conduct an initial hydrogeologic study at Lajes Field, Azores, Portugal. This study was initiated to investigate the groundwater aquifers which underlie the already identified suspected and contaminated sites of Lajes Field and to determine any resulting risk. It was programmed to gain basic information on the groundwater situation that could help to understand possible pathways and risk to receptors in support of the HQ USAFE restoration program.

There are two kinds of aquifers present in the Lajes area:

1. A "basal" aquifer that occurs in very permeable fractured volcanic rocks and has groundwater levels near sea level.

2. Numerous discontinuous perched aquifers that occur in areas where precipitation that infiltrates the surface is impeded by lower permeability materials in the subsurface, such as paleosols or low permeabilty lava flows.

The basal aquifer is the only source of groundwater supply to Lajes Field. The wells in the Base well field tap a thin (approximately 18 to 20 m thick) freshwater lens. Upconing of saline water in to these wells is possible if the wells are pumped at excessive rates or/and if the pumps are not installed at the correct levels in the basal aquifer

The well field draws water from as much as 7 km upgradient (southwest) of the well field. There is no indication that the Base well field could obtain any water from potentially contaminated areas onbase. However, the abandoned Cabrito pipeline (DISCO Site 5013) is crossing the simulated source area for the Base well field and together with agricultural or other activities that occur within the capture zone of the Base well field could impact the quality of water pumped from the Base wells.

The following improvements are recommended at the Base well field:

- Improve access to the well casing for each of the Base wells
  - Groundwater levels in the Base wells are difficult to measure because of obstructions at the top of the well and within the well casing itself. Monitoring of groundwater levels in the Base wells should be performed frequently. In addition, with improved access, the depth to the salt water interface should be monitored frequently to avoid upconing of salt water into the well.
- Evaluate the potential for upconing of salt water at each well in the well field
  - After access to the well casing is improved, the potential for upconing of salt water due to over pumping of the well should be conducted. Measurements of the position of the salt water interface should be done for both pumping and non-pumping conditions. The field data should be used to perform a theoretical analysis of the potential for upconing under several different assumptions of well pumping rate, duration of pumping and depth of the well intake.
- Recommend improvements to operation of the Base well field

- Based on the results of the upconing analysis, recommendations for the operation and monitoring of the Base well field should be developed. These would include recommendations on pumping rate and duration, placement of the pump, frequency of monitoring and techniques of monitoring.

The perched aquifers in Lajes area are compartmentalized by faults; the groundwater flow directions are controlled by the presence of local fault boundaries and the extent of the perching layers. Numerical model simulations suggest that groundwater in the perched zones moves only a few hundred meters laterally before leaking downward to the basal aquifer.

To help support future investigation activities at Lajes Field, a numerical model of the groundwater flow system was developed. Only limited data were available from calibration of the model, but were sufficient to develop approximate forecasts of groundwater flow directions in the basal and perched aquifers. It is likely that local hydrogeologic properties will depart from the current assumptions in the model. However, the model is believed accurate enough to choose locations for monitoring wells near known sites of contamination.

Additional information on the groundwater quality and flow directions is needed in the surrounding of the known contaminated sites with the prospect of doing risk assessments to balance the risk for potential receptors.

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SECTION 1.0

Introduction and Background

CH2M HILL was contracted by the Air Force Center for Environmental Excellence (AFCEE), at the request of the United States Air Forces in Europe (USAFE), to conduct an initial hydrogeologic study at Lajes Field, Azores, Portugal. The intent of this document is to describe the data-gathering efforts that were undertaken at Lajes Field in 2003/2004 and to present an evaluation of those data. Activities during this investigation were performed under AFCEE Contract No. F41624-03-D-8595, Task Order 0085.

1.1 Overview of Lajes Field

Lajes Field is located on Terceira Island, one of the central islands of the Azorean archipelago, Portugal (see Figure 1-1). The Base consists of approximately 580 hectares/, 1450 acres contained within one functional area, located on the northeastern part of Terceira island. The Base is owned and operated by the Base Aérea No. 4, run by the Portuguese Air Force (Estadas Major Forca AéreaEstado Maior da Força Aérea). Due to its geopolitical location, the Base is also referred to as being the "Crossroads of the Atlantic". Lajes main mission is to support the United States and Allied forces operating in the Atlantic Ocean. Lajes Field is primarily used as a refueling station for aircraft. The Base was founded by the British Royal Air Force in 1943 and based on an interim agreement (December 1943) between the United States and Portugal, the USAF first utilized Lajes Field mainly for maintaining troops and equipment supply during World War II.

1.2 Project Scope

This study was initiated to investigate the groundwater aquifers which underlay the already identified suspected and contaminated sites of Lajes Field (DISCO Study, CH2M HILL, 2003) and to determine any resulting risk. It was programmed to gain basic information on the groundwater situation that could help to understand possible pathways and risk to receptors. This study was conducted to support the HQ USAFE restoration program. Useful byproducts, which can help to solve other concerns, are welcome, but not initially intended under the scope of work.

The project objective was to obtain as much hydrogeological data as possible on the groundwater aquifer that underlies Lajes Field and surrounding areas. After obtaining these data, a preliminary numerical groundwater model of the area was developed. With this preliminary model, it is possible to obtain preliminary evaluations of the potential pathways from contaminated areas to assess possible risks to humans and the mission. Recommendations for additional data (such as installing additional wells) are presented to fill data gaps to better understand the groundwater aquifer. In addition, data collected during this project are of assistance in assessing the long-term viability of the water supply for the Base, although that was not the major objective of this study.

The main focus of this hydrogeological study is in support of the HQ USAFE restoration program. The hydrogeological study is therefore a vital tool for the risk assessment of suspected and known contaminated sites at Lajes Field, public drinking water supply, and human health.

This study initiates a multiphase program to understand the hydrogeological situation at Lajes Field and vicinity in greater detail.

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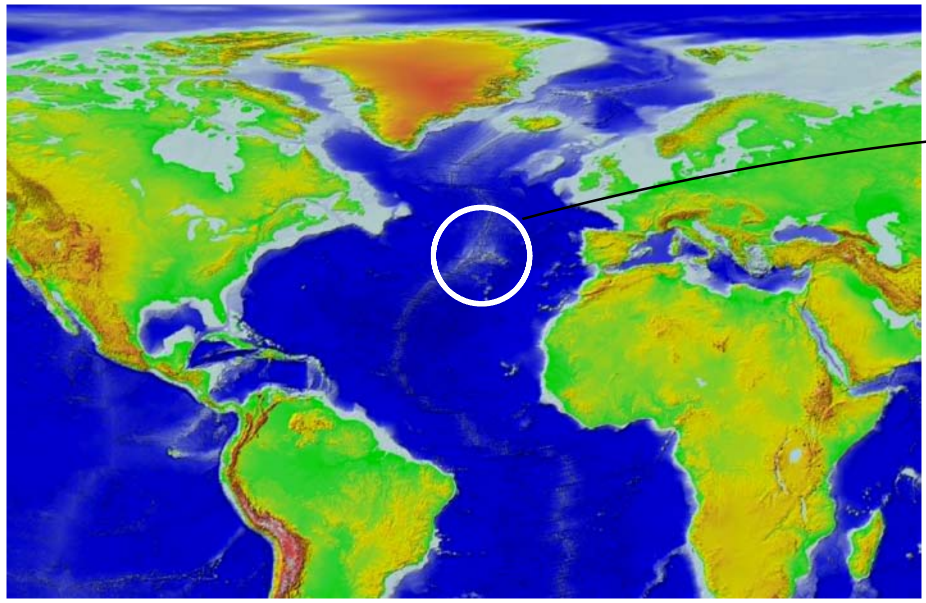

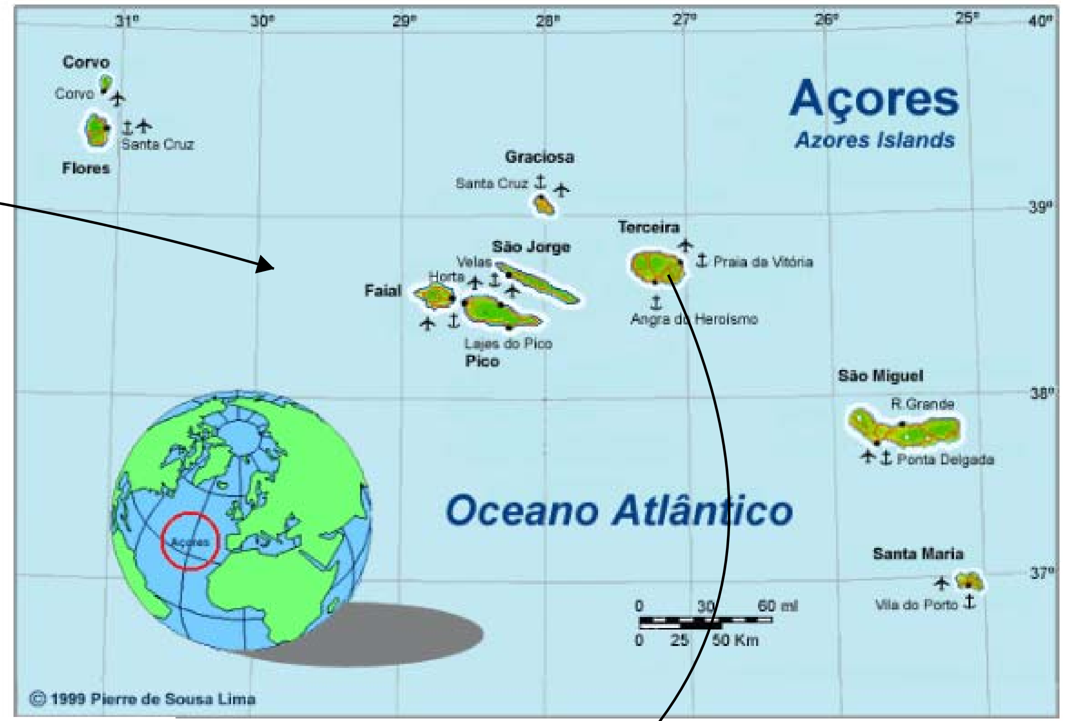

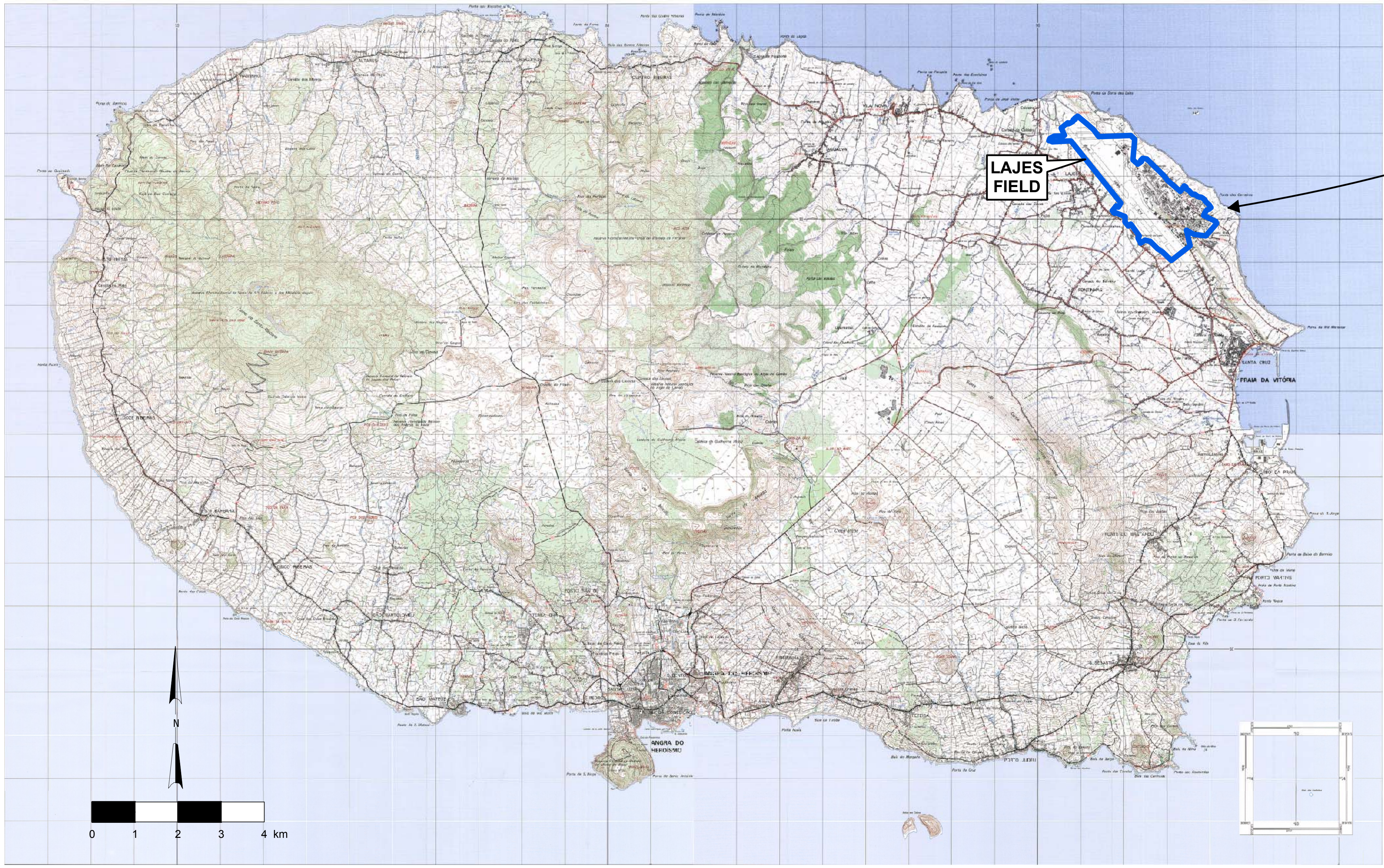

FIGURE 1-1
LOCATION OF LAJES FIELD
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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SECTION 2.0

Work Accomplished

2.1 Field Trips September 2003, July 2004, and September 2004

CH2M HILL combined the kick-off meeting for this project, held on 11 September 2003 at the CE building (T-570) at Lajes Field with an initial data gathering to better understand the local geological and hydrogeological situation and available information. Based on this initially collected information, the work plan was prepared (CH2M HILL, 2004). During this initial site visit contacts were made to potential subcontractors for a well canvass study and to establish a relationship to Dr. Francisco Cota Rodrigues, a local hydrogeologist from the University of the Azores.

A second site visit in late June, early July 2004 comprised the investigation of the monitoring wells at the South Tank Farm and of the Lajes Field Base water supply wells. This effort was combined with an initial water sampling and analytical program conducted under TO 184 – Risk Assessment of Out of Service Storage Tank Sites. Our local subcontractor VIVA conducted in parallel the well canvass of Lajes Field monitoring wells, water supply wells, as well as of private wells and City of Praia water supply wells in the proximity of the investigation area.

A final site visit to Terceira Island took place beginning of September 2004 to discuss initial results of the well canvass study together with VIVA and Mr. Rodrigues and to fill last data gaps on accessible information from Lajes Field.

2.1.1 Well Canvass

The objective of the well canvass was to collect additional data that would significantly assist in developing the hydrogeologic model of the Lajes Field area. All data collected during the well canvas phase can be found in Appendix A; locations of all investigated wells are plotted in Figure 2-1.

The well canvass, conducted by our local subcontractor VIVA in cooperation with Mr. Francisco Rodrigues from the University of the Azores included the following activities:

1. Survey of location and elevation of the existing Lajes Field water supply wells, South Tank Farm monitoring wells, offbase private wells and water supply wells of the City of Praia in the proximity of Lajes Field. These location and elevations have been determined to an accuracy of 1 cm using high resolution GPS technology.
2. Whenever possible additional information in regard to the different wells has been
   - Well Name
   - Use of Well (Domestic, Abandoned, etc.)
   - Well Yield
   - UTM Coordinates
   - Land Surface Elevation
   - Measuring Point Elevation
   - Well Depth
   - Well Diameter
   - Depth to Static Water Level

- Depth to Pumping Water Level
- Well Construction (Dug Well, Drilled Well Etc)
- Type of Well Casing
- Geologic Log of Well
- Well Construction Log
- Type of Pump
- Pump Size (impeller diameter, horsepower, yield, etc)
- Water Quality Sample Results
- Electrical Conductance of Water

2.1.2 Testing of Base Wells

CH2M HILL used Solinst Model 3001 LT Levelloggers with a pressure transducer and temperature sensor to measure groundwater level fluctuations in Well 8, Well 3, and Well 1. All other Lajes Field Base wells couldn’t be measured based on insufficient access ports or obstacles inside the well casing that prevented the use of the Levelloggers. The dataloggers were installed on 2 July 2004 and have been removed on 8 July 2004. A Solinst Barologger was used for a subsequent barometric compensation of the measurements. In addition conductivity profiles of the water table - using a Solinst Model 3001 LTC Conductivity Levellogger - were obtained in Well 8, Well 3, and Well 1 on 9 July 2004.

All results related to these measurements are discussed in Section 4.0.

2.2 Consultation with Francisco Cota Rodrigues, University of the Azores

As part of this study, CH2M HILL worked with Dr. Francisco Cota Rodrigues, a professor at the University of the Azores. Dr. Rodrigues wrote his PhD thesis on the hydrogeology of Terceira Island, including the Lajes area, making him one of the most knowledgeable people on the specific hydrogeologic issues in the Lajes area. Much of the work that he has done in the past, such as water balance estimates, were included in the numerical groundwater flow model that was developed during this study. During model development, Dr. Rodrigues assisted in the conceptualization of the model and reviewed some early versions of the model during discussions with him on Terceira in September 2004.

LEGEND

- LAJES SPRING
- LAJES – BASE WELL
- LAJES – SHALLOW PRODUCTION WELL
- FONTINHAS – SHALLOW PRODUCTION WELL
- FONTINHAS – CITY OF PRAIA
- JUNCAL – SHALLOW PRODUCTION WELL
- JUNCAL – CITY OF PRAIA
- PRAIA – SHALLOW PRODUCTION WELL
- PRAIA – CITY OF PRAIA
- PAUL – SHALLOW PRODUCTION WELL
- SANTA LUZIA – SHALLOW PRODUCTION WELL
- S. BRAS – CITY OF PRAIA
- SOUTH TANK FARM MONITORING WELL

FIGURE 2-1
LOCATION OF WELLS INCLUDED IN THE WELL CANVASS
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LAJES FIELD, PORTUGAL

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SECTION 3.0

Hydrogeology

3.1 Hydrogeologic Setting

3.1.1 Climate

The climate of the Azorean Archipelago is largely governed by the North Atlantic Gulf Stream. Because of the strong oceanic influence the climatic fluctuates less than in continental areas of similar latitudes.

The seasonal variations of the Azorean climate are changes in temperature and rainfall, with a cold and rainy period between October and March and a relatively warm and wet period during the rest of the year.

The climatic description is based on data from the Observatório Meteorologico Ten. Cor. José Agostinho in Angra do Heroísmo (Terceira, south coast, 77 m msl) and from Lajes Air Field (Terceira, east coast, 53 m msl) yielding comparable climatic characteristics.

The average annual temperature is about 17º C in Angra and Lajes. The annual temperature variations are low, with a maximum around 29º C in August, and a minimum around 11º C in February. The average annual precipitation is about 810 to 1210 mm in the Lajes area, with the lowest values between May and August, and the highest rainfall between October and March. The relative humidity is high with annual values exceeding 77 percent in both stations, with lowest values between July and October.

Consistent with other Azorean islands, climatic parameters at Terceira Island are significantly overprinted with the elevation. In general the temperature gradient, highly influenced by the humidity, is changing about 0.6º C/100 m of elevation (Bettencourt, 1977), with a small increment in the northern slopes of the island. The total precipitation is closely related to altitude, which is tentatively defined by Agostinho (1942), Bettencourt (1977), Rodrigues (1995), and Azevedo (1996).

Applying statistical methods Bettencourt (1977) consider that the distribution of precipitation in Terceira Island can be defined by the expression:

$$Ra = 2{,}18\ z + 961 \qquad (1)$$

Where:

Ra = the annual precipitation in mm
z = the altitude in meters.

Rodrigues (1995) comparing data of San Miguel and Koolau (Hawaii) considers that the distribution of precipitation in the Azores can be defined by the expression:

$$Pa = a1Za2 + b1\ L1 + c1\ S0\ f1 + d1\ Zmax \qquad (2)$$

Where:

Pa	=	the annual precipitation (mm)
a1, a2, b1, c1, and d1	=	coefficients determinate by local calibrations
Z	=	the altitude (m)
S0	=	the inclination of field (%)
L1	=	the distance to the sea (m)
f1	=	degree of topographic depression
Zmax	=	the altitude of the main obstruction to the oceanic air masses from SW.

Azevedo (1996) developed a model in a GIS system - the CIELO model - to generalize climatic elements like precipitation, temperature and evapotranspiration, in small oceanic islands. The CIELO model was developed in Terceira Island with data from Angra do Heroísmo and Lajes meteorological stations, considering the physical schemes that represent the processes inducing the local climate characteristics (see Figure 3-7).

3.1.2 Geomorphology

Terceira Island is located in the central group of the Azores Archipelago, between 38º 38′ 10′′ and 38º 47′ 40′′ N latitude and 27º 03′ 00′′ and 27º 24′ 00′′ W longitudes. Like the other Azorean islands, it is part of Macaronesia, the Atlantic insular region that includes also the archipelagos of Madeira, Selvagens, Canary, and Cape Verde Islands.

Terceira Island is built by tree volcanic massifs: the composite volcanoes of Cinco Picos, Guilherme Moniz and Pico Alto. The Lajes graben is the north-eastern sector of Cinco Picos composite volcano (see Figure 3-1).

The Cinco Picos composite volcano (151,1 km^2) – the oldest volcano of Terceira – is located in the eastern portion of the island. Its morphology is characterized by the tectonic grabens of Lajes to the NE and Grota do Vale to the SW and by the Cinco Picos caldera in the center. The mountains of Serra do Cume and Serra da Ribeirinha are located between these tectonic depressions, actually represent the NE and SW slopes of the old volcano (see Figure 3-1).

The Lajes graben is a tectonic depression stretching between the slopes of the Santiago and Fontinhas faults. However, many additional smaller faults in this plane surface further dissect this area into smaller fractions.

The line defined between the places of Juncal and Santa Luzia, corresponding to the SE sector of the airport, marks the boundary of the two sectors of the Lajes graben: the southern, with general slope of the land surface to the southeast and the northern, with land surface sloping to the northwest.

3.1.3 Soil and Vegetation

According to Pinheiro (1990) the soils in the Lajes graben area are predominantly typical Andosols. These volcanic soils are characterized by a high permeability up to 70 percent in some cases (Faria, 1974).

The vegetation in Lajes graben is mainly grassland (70 percent) and agricultural (20 percent, mainly cornfields). Small horticultural areas and vineyards are situated around the villages (6 percent).

The florets have an extent of 4 percent covering recent lava flows (Biscoito das Fontinhas and Caldeira das Lajes). In the elevation of Lajes graben floor there are no significant phenomena of fog interception by the trees, although this is a significant part of the precipitation in higher elevation areas of Terceira.

3.1.4 Geology

Terceira is a young volcanic island, built of igneous rocks and some sedimentary deposits. Thus, the rocks of Terceira can be divided into two groups: (1) Quaternary igneous rocks and (2) Pleistocene-recent sediments. The distribution is shown on the geological map presented in Figure 3-2.

3.1.4.1 Quaternary Igneous Rocks

The Quaternary igneous rocks are predominant on Terceira. The volcanic eruption centers were Cinco Picos, Guilherme Moniz, Santa Bárbara and the central rift zone.

Self (1976) divides the igneous rocks of Terceira into two groups: the Lower Terceira Group and the Upper Terceira Group. He defined the Base of the Upper Terceira Group by two extensive ignimbrite deposits – the Lajes and the Angra Ignimbrites - with an age of approximately 20000 and 23000 years, respectively.

Lloyd and Collis (1981) further subdivided these two groups into ten volcanic formations: (1) Cinco Picos Trachybasalt Formation; (2) Guilherme Moniz Trachite Formation; (3) Santa Barbara Basalt Formation; (4) Lower Terceira Basalt Formation; (5) Lower Terceira Ignimbrites Formation; (6) Angra Ignimbrite Formation; (7) Lajes Ignimbrite Formation; (8) Pico Alto Peralkaline Volcanic Formation; (9) Biscoitos Breccia Formation; and (10) Upper Terceira Basalt Formation.

The formations that built the area investigated are the Cinco Picos Trachybasalt Formation, the Lower Terceira Basalt Formation, the Lajes Ignimbrite Formation and Upper Terceira Basalt Formation.

In this study we have grouped the Terceira lavas following Self (1971, 1976), Self and Gunn (1976), Lloyd and Collis (1981) and Fernandes (1985). For pyroclastic materials these authors adopted the classification suggested by Sparks (1976)1 and for lava flows the classification of Thompson et al. (1972) using the Thornton and Tuttle differentiation index (D.I.)2.

[1] Pyroclastic fall, pyroclastic surge and pyroclastic flow.

[2] Alkali-olivine basalts with a D.I.<35, hawaiites with a D.I. between 35 and 45, mugearites with a D.I. between 45 and 65, benmoreites with a D.I. between 65 and 75 and more salic types with a D.I > 75.

3.1.4.2 Cinco Picos Trachybasalt Formation

Lloyd and Collis (1981) and Fernandes (1985) gave the name Cinco Picos Trachybasalt to the oldest exposed lava flows and subordinate tephra that occurs in Terceira Island, that forms the bedrock of the Cinco Picos strato-volcano.

The pyroclastic materials are mainly airfall deposits of bombs, lapilli and scoria near the vent sources. Self and Gunn (1976) recognized in the lava flows ankaramitic basalts, hawaiites and undersaturated trachytes.

The Cinco Picos Trachybasalt materials were erupted from a central vent before the summit collapsed to the Cinco Picos Caldeira and from small adventive cones that flank the strato-volcano. The sequence of lava flows/tephra deposits is product of strombolian-type volcanism.

The Cinco Picos Trachybasalt formation forms the bedrock of the Lajes depression. It is exposed in the fault scarps of Fontinhas, Barreiro, Boavista, S. Lázaro, Santiago, and in the coastal cliffs extending between Caldeira das Lajes, and Forte do Espírito Santo, and between Poço da Areia, and Cabo da Praia (see Figure 3-3). All the wells built in the Base of Lajes graben intercept this material.

The NE coastal cliffs of Serra de Santiago, the typical rock of this formation is approximately 90 m thick, consist of seven lava flows, interbedded with air-fall deposits of scoria, bombs and lapilli. The frequent "buried" pedologic levels (paleosoils), provide evidence of volcanic quiescence periods.

From the hydrological point of view, the lava flows are very heterogeneous, with the top and bottom clinker levels that are generally very permeable, but with the central part of the flows consisting of compact rock with few fractures and of relative low permeability. Near the faults, the lava flows presents normally a high density of fractures, and, consequently, high permeability.

The tephra deposits are generally very permeable. Paleosols and the weathered pyroclastic materials normally have low permeability, often resulting in small perched aquifers.

3.1.4.3 Lower Terceira Basalt Formation

The Lower Terceira Basalt formation correspond to basaltic lava flows and subordinate tephra, with origin in central fissure zone and volcanic vents in the flanks of Guilherme Moniz and Cinco Picos massifs.

The pyroclastic materials are airfall deposits of bombs, lapilli and scoria near the vent sources. Ankaramitic basalts with olivines and hawaiites mainly compose the lava flows.

In the studied area these materials overlie the Cinco Picos Trachybasalts, occurring in the floor of Caldeira das Lajes and Cabo da Praia.

3.1.4.4 Lajes Ignimbrite Formation

Lajes ignimbrite is the name given by Self (1976) to the youngest widespread ignimbrite on Terceira Island, erupted by the Pico Alto Volcanic Center approximately 19,680 years ago (Shotton et al., 1984).

Lajes ignimbrites have a comenditic-trachitic composition, with fiamme of dark glass and abundant lithic inclusions of trachyite and basalt. It is possible to identify abundant crystals of sanidine and aegerine-augite in the glassy materials.

The deposits are normally strongly welded in the Base, decreasing progressively to the top. The upper parts are generally moderately compacted, with signs of weathering in some levels. In general, the size of the clasts increases towards the top.

Hydrologically, these pyroclastic flows are very permeable, with abundant fractures in the compact basal and central flow paths.

In the Lajes graben floor, the Lajes Ignimbrites overlie an extensive paleosol[3] and the Cinco Picos trachybasalts, between the localities of Santa Luzia (Praia da Vitória) and Caldeira das Lajes (Lajes). In this last locality this pyroclastic rocks reach up to 15 m thick on the NE slopes of the "caldeira" depression and in the coastal cliffs, between Ponta de José Vieira and Vila Nova (see Figure 3-3).

The Lajes Ignimbrites formation overlies also the Cinco Pico Trachybasalts in the NE portion of Serra da Santiago, especially in the vicinity of the Santiago fault cliffs (see Figure 3-3).

3.1.4.5 Upper Terceira Basalt Formation

Upper Terceira Basalt is the name proposed by Lloyd and Collis (1981) for the basaltic lava flows and subordinate tephra, erupted on Terceira Island in the last 23,100 years. The Upper Terceira Basalts were divided by Fernandes (1985) into eight members, with origin in vents disposed in the central fissure zone and in the flanks of Serra do Cume (Fonte do Bastardo and Pico Celeiro).

The composition of the Upper Terceira Basalts range from alkali-olivine basalt to mugearites (Fernandes, 1985). The lava flows, clearly dominant, in general from the "aa" type, does not exceed a thickness of 5 m. The pyroclastic materials are air-fall deposits of bombs, lapilli and scoria.

In the Lajes graben the Upper Terceira Basalts have two main vent sources: the Pico Celeiro, directly disposed in the Fontinhas fault (Pico Celeiro Upper Basalts) and the Algar do Carvão vents in the central fissure zone (Algar Upper Basalts).

The Pico Celeiro Upper Basalts are located between Pico Celeiro and W of Praia da Vitória (Poço da Areia-Belo Jardim), overlaying the Trachybasalts of Cinco Picos. The Algar Upper Basalts are located at W of Lajes village, overlaying the Lajes Ignimbrites and also the Trachybasalts of Cinco Picos.

3.1.4.6 Pleistocene to Recent Sediment

The Pleistocene-Recent sediments consist of dunes, beach sand and accumulations of weathered tephra.

The dunes and beach sand form the Praia da Vitória beach at the SE coast of Lajes graben. Some rounded beach cobbles deposits are located at the NW of Lajes graben (Caldeira das Lajes and Baía da Caldeirinha) and in the basis of the NE and S cliffs of Serra de Santiago (Baía do Zimbral and Ponta da Má Merenda-Forte do Espirito Santo).

Deposits of rounded cobbles (1 km wide and 7 to 10 m msl) were mentioned by Berthois (1951) behind the sand dunes at Praia da Vitória and Cabo da Praia. Rodriguez confirmed this level in some wells of Cabo da Praia (Canada dos Pastos), Praia da Vitória (Boavista) and in the slopes of Ribeira de Santo Antão.

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[3] This pedologic level have a medium thickness of 0,5 m, with a maximum of 1,3 m and a minimum of 0,30 m.

Lloyd and Collis (1981) reports some rounded basalt cobbles up to 10 m elevation on the pahoehoe lava flooring Lajes Caldeira, interpreted as old beach levels that mark probably a higher late-Pleistocene sea level.

Deposits of weathered tephra and cobbles are identified in the Lajes graben faults scarps, especially in Santiago and Fontinhas faults.

3.1.5 Tectonic

The Atlantic region of the Azores is dominated by the triple junction between the European, American and African Plates, that together configure the Azores micro-plate (Forjaz, 1988) (see Figure 3-4).

The boundary between the American plate and the European plate is the Mid Atlantic Ridge (MAR). This important spreading centre trends between 10º and 20º and passes West of Flores and Corvo Islands.

The boundary between the European and the African Plates – south limit of the Azores micro-plate (Forjaz, 1988) is the East Azores Fracture Zone(EAFZ) (Laugton and Witemarsh, 1974). This tectonic feature is collinear with the Gloria fault (Azores-Gibraltar), a volcano-tectonic lineament with connection to the Mediterranean fault systems.

The NE limit of the Azores micro-plate is a spreading centre trending about 125º, composed of several en echelon rifted basins, with submarine and subareal volcanoes, collectively called Terceira rift by Machado (1959). According to Searle (1980), the components of this volcano tectonic structure includes the Terceira Ridge, which is an important volcano-tectonic lineament and probably responsible for the island existence.

The Cinco Picos strato-volcano, an element of Terceira Ridge, dominates Terceira in the East. It was the first volcano in the island to emerge from the ocean, probably in the Quaternary (Lloyd and Collis, 1981). The Cinco Picos volcano is marked in the field by three main depressions bounded by faults that trend between 115º and 148º: the Grota do Vale depression in the West; the Cinco Picos caldera in the center; and the Lajes graben in the East.

Many geologists consider the Cinco Picos volcano extinct. However Lloyd and Collis (1981), believes that future strombolian basaltic eruptions in the center of Cinco Picos caldera and from random sites on his SE flanks could be expected.

Lajes graben, in the eastern sector of Cinco Picos volcano, is a tectonic element of the Terceira Ridge. The dominant directions of its main faults – Fontinhas Fault and Santiago Fault – are NNW-SSE, parallel to the trend of this important volcano-tectonic structure (see Figure 3-5).

The Santiago Fault is the NE limit of Lajes graben and is marked by a sub-vertical scarp with an elevation of more than 100 m in some areas, which trends 141º.

In the wall of the Santiago fault that is defined between Forte do Espirito Santo (Praia da Vitória) and Caldeira das Lajes (Lajes) thick lava flows are exposed (mainly hawaiites and mugearites), pyroclastic deposits (lapilli) and sediments (weathered tephra and cobbles).

The Fontinhas Fault that bounds Lajes graben to the SW is marked by rugged scarps, well developed between Cabo da Praia and Pico da Rocha, with a sinuous profile. It

trends between 115º and 148º, but the more east-trending sections appear to be splinter scarps. In the wall fault there are lava flows, pyroclastic deposits and important sedimentary accumulations of weathered tephra.

A complex fault system can be found at the floor of Lajes graben, marking distinct compartments in the field - S. Lázaro fault, Boavista fault and Barreiro Fault (see Figure 3-6).

The S. Lázaro Fault is marked by a scarp with an elevation of 30 m, well developed between Paul da Praia da Vitória and Santa Luzia, that trends between 120º and 130º. In the southern wall of this fault there are exposed lava flows with scoria and lapilli levels.

3.1.6 Geohazards

The islands of the Azorean Archipelago, and therefore Lajes Field at Terceira Island could be prone to volcanism, earthquakes, and tsunamis:

3.1.6.1 Volcanism

Reports of seismic and volcanic events date from the beginning of the settlement of the Azorean islands in the 15th century. Volcanically, Terceira Island is still active, although the last land based eruption occurred in 1761 from Pico Alto volcano. Today an active, quite shallow and exploitable high temperature geothermal field is located beneath Pico Alto. Currently there is a new, active submarine volcano just 10 km W of the island. The location of the submarine eruption is known as 'Serreta High'. Some fishermen made the first observation of this activity shortly after the local Azorean Seismic Network registered micro-seismic activities on 18 December 1998. The eruption is not continuous with an absence of surface manifestations of the volcanic activity most of the times.

During the last 500 years, a significant number of submarine eruptions have occurred. Close to the location of the current volcanic activity, a catastrophic submarine eruption took place in 1867. This historic eruption was preceded by premonitory tremors that lasted 5 months and culminated in violent earthquakes and explosive volcanism for a week and severely damaged Terceira Island.

3.1.6.2 Earthquakes

The higher risk of seismic hazards in the Azorean Archipelago is due to its location near the plate boundary between Africa, Eurasia, and North America. Terceira Island, located in the Central Group of the Azorean Archipelago, builds the NE edge of the Azores Microplate next to the Terceira Rift, has suffered several strong earthquakes. The last devastating earthquake, with a magnitude of 7.2 occurred on 1 January 1980 with several casualties and extensive damage, in particular in Angra do Heroismo.

3.1.6.3 Tsunamis

Tsunamis can be generated either by earthquakes or landslides. One example is the tsunami triggered by a magnitude 8.6 earthquake on 1 November 1755 at 'Gorringe Bank', a submarine ridge off the coast of Portugal. The earthquake destroyed much of Lisbon, Portugal. At least three great waves about ten meters high entered the city only minutes after the earthquake. The waves also raked the nearby coasts of Spain and North Africa, and did extensive damage in the Azores, Madeira, and Canary Islands.

3.2 Water Balance

3.2.1 Precipitation

According the simulation of the CIELO model presented in Rodrigues (2002) the annual atmospheric precipitation in the Lajes graben is not homogeneous, ranging between 810 mm and 1,210 mm. In the northern, eastern and southern sector the mean value is 910 mm and in the west and central area 1,110 mm (see Figure 3-7).

The average annual precipitation observed in the Lajes Air Field meteorological station is 1,063 mm between 1951 and 1995. According to Rodrigues (2002) in Lajes Caldeira in 1998 and 1999 the atmospheric precipitation was 1,045 mm and 750 mm, respectively.

In the Lajes graben area there are no important phenomena of cloud milking and dewfall, common in Terceira Island areas with an altitude above 500 m.

An average annual precipitation of 1,000 mm can be assumed as representative for the entire Lajes depression.

3.2.2 Evapotransportation

According the simulation of the CIELO model presented in Rodrigues (2002) the average annual evapotranspiration values estimated for the Lajes graben depression range between 636 mm and 791 mm. The SE sector presents the highest values, which change between 714 mm and 791 mm.

An average annual value of 686 mm can be assumed as representative for the entire Lajes depression.

3.2.3 Surface Runoff

According to Rodrigues (2002) there are in the Lajes graben area 5 hydrologic catchments that are well defined, corresponding to the torrential small rivers (ribeiras) of Belo Jardim, do Tapete, dos Pães, Santo Antão and Santa Catarina. Most of the surface of these depressions has an unstructured surface runoff system, without important rivers (see Figure 3-8).

No measured data exists about surface runoff in the hydrologic catchments of Lajes graben.

In the literature several values are appointed for island with similar characteristics to Terceira. Wright (1989) estimates an average runoff coefficients (Ke) of 0.2 for Kahoolawe and 0.44 for Maui (Hawaii), Heras (1974) values of 0.14 and 0.13 for Gran Canaria and Lanzarote (Canary Islands), Berndtson (1984) a value of 0.33 for Cape Vert and Rogber (1984) 0.27 for Mauritius Island.

In the cliffed island of Flores (Azores) Azevedo (1998) estimates a Ke of 0.28. Fontes (1999) measured an annual surface runoff in Cinco Picos massif hydrologic basins, which range between 0.01 and 0.17 respectively in grassland areas and during agricultural soil mobilizations.

Rodrigues (2002) considers a Ke-value of 0.32 for the entire Terceira island water balance, based on the Azevedo et al. (2001) model, tested with flow discharge measurements in Santa Barbara small rivers.

We believe that a runoff coefficient of 0.42 can be assumed as representative for the entire Lajes depression area, considering the soil occupation and the low land declination.

3.2.4 Groundwater Recharge

Based on water balance evaluation, the average annual amount of groundwater recharge in the Lajes graben area is approximately 272 mm/yr (See Table 3-1).

TABLE 3-1
Water Balance Summary of Lajes Graben

Water Budget Component	mm/year	Percent
Precipitation	1,000	100
Evapotranspiration	686	68.6
Surface Runoff	42	4.2
Groundwater Recharge	272	27.2

Groundwater recharge occurs in the Lajes graben naturally, from soil water percolating below the root zone and from infiltration of streamflow along water courses, especially along the Fontinhas fault cliffs.

3.2.5 Groundwater Discharge

Groundwater discharge occurs principally from springs or streams along the coastline (mainly diffuse submarine springs and in interior cliffs (Fontinhas springs, Caldeira das Lajes spring) or coastal cliffs (Amoreiras and Zimbral diffuse springs). According to Rodrigues (2002), there is chemical evidence that the groundwater discharge in the coastal springs occurs by mixing with seawater below the island.

In Lajes graben there are 20 springs, the majority of the springs are located in the Fontinhas fault (17) and just one in the floor of the Lajes depression, in the eastern cliff of Caldeira das Lajes. There are diffuse springs in the SE coastline, in Praia da Vitória, only visible during the low tidal period (Poço da Areia and Paul).

In the seafloor of Praia da Vitória bay and near Caldeira das Lajes, there are freshwater springs (Rodrigues, 2002).

The Fontinhas springs are located in the cliff of Fontinhas fault and in the floor of some water lines. The total flow ranges between 26 l/sec in winter and 10 l/sec in summer and the water has a low mineralization.

The Caldeira spring is located at the west cliff of Caldeira das Lajes, in the Base of Lajes Ignimbrite deposit. The average flow of this spring is less than 1 l/sec, ranging between 0.1 l/sec in summer and 0.09 l/sec in winter (Rodrigues, 2002) (see Figure 3-9).

Groundwater discharge also occurs by pumping from water supply wells. Lajes Field pumps approximately 0.54 MGD (750,000 m^3/yr). There is also pumping from municipal supply wells operated by the City of Praia da Vitoria. The total amount of pumping from these City wells is unknown.

The diffuse springs located at Praia da Vitoria have a high flow, and waters with a high mineralization (freshwater mixed with saltwater).

3.3 Hydrogeologic Regime

The geological formations of that underlie Terceira island are very heterogeneous and anisotropic, with very permeable materials associated with lava flows and materials, interbedded with lower permeability layers related to paleosols and weathered pyroclastics.

In general, the lava flows appear to be very permeable, since they exhibit intense primary and secondary fracturing, highly developed breccia zones, a large number of cavities, and a low degree of alteration. The paleosols effectively act as impermeable layers, as do the weathered pyroclastic horizons.

The Cinco Picos Trachybasalts – the oldest rocks of Terceira Island – exhibit a low degree of weathering, an intense fracturing (especially near the faults), and a high percentage of small cavities and pores. These conditions are naturally favorable to a high permeability.

The Lajes Ignimbrites flows appear to have high permeability, given the considerable vertical fracturing exhibited and the absence of a structured field drainage system in the overlying fields.

3.3.1 Aquifers

There are two kinds of aquifers present on Terceira:

1. A "basal" aquifer that occurs in very permeable fractured volcanic rocks and has groundwater levels near sea level.
2. Numerous discontinuous perched aquifers that occur in areas where precipitation that infiltrates the surface is impeded by lower permeability materials in the subsurface, such as paleosols or low permeability lava flows

These are illustrated schematically in Figure 3-10. A north-south section through Lajes graben is shown on Figure 3-11. The principal aquifers are discussed below:

3.3.2 Basal Aquifer

The high permeability of the volcanic rocks of Terceira are favorable for seawater intrusion of the entire island at elevations below sea level. In these conditions, there is a continuous body of saltwater beneath the island, with a lens of freshwater floating on it, generically called the *Basal Aquifer*. The thickness of the freshwater lens is greater in areas where the rock permeability is relatively low and thinnest where the rock permeability is high. The thickness of the freshwater lens can be approximated by the Ghyben-Herzberg approximation that states that the depth of freshwater below sea level would equal to 40 times the elevation of the water table. For example, if the water table elevation is +1 m above sea level, then the Base of fresh water occurs at depth of 40 m below sea level so the thickness of the freshwater lens would be 41 m. The Ghyben Herzberg approximation assumes a sharp interface between fresh water and salt water. However, typically these two water bodies are separated by a transition zone, containing a mixture of freshwater and saltwater, with a thickness controlled by tidal fluctuations, upconing due to groundwater pumping, seasonal recharge and dispersion during groundwater flow. The transition zone limit can be defined arbitrarily as a body with 1 percent to 95 percent seawater content, based on total dissolved solids or chlorine contents.

In some highly heterogeneous zones, such as in faults, the transition zone can occupy a significant part of the aquifer, with an upper limit being close to the water table.

During the well canvass, groundwater levels for several wells that tap the basal aquifer were collected. These data are plotted on Figure 3-12.

3.3.2.1 Aquifer properties

Although the basal aquifer is typically very permeable, only a few measurements are available to quantify the aquifer properties. Table 3-2 presents a list of available aquifer transmissivity values based on specific capacity testing. The transmissivity is computed from specific capacity by the formula:

$$T\ (m^2/d) = 7.6 \text{ times the specific capacity of the well (gpm/ft)} \qquad (3)$$

TABLE 3-2
Transmissivity of the Basal Aquifer from Specific Capacity Tests

Well	Transmissivity (m^2/d)	Reference
2	5190	Well records
4	2510	Well records June 20-July 9 2004
5	4605	Well records June 20-July 9 2004
8	15012	Well records June 20-July 9 2004
9	10295	Iceland Drilling Step Test
9	12131	Iceland Drilling Step Test
9	6220	Iceland Drilling Step Test
9	7545	Iceland Drilling Step Test
9	7727	Iceland Drilling Step Test
9	10110	Iceland Drilling Step Test
10	14414	Iceland Drilling Step Test
10	10660	Iceland Drilling Step Test
10	13212	Iceland Drilling Step Test
10	14671	Iceland Drilling Step Test
10	15239	Iceland Drilling Step Test
10	14113	Iceland Drilling Step Test
Juncal 1	1296	Rodrigues (2002)
Juncal 2	2349	Rodrigues (2002)

Based on these data, it is assumed that the typical transmissivity of the aquifer in the area of the Base well field is about 14,000 m^2/d.

3.3.2.2 Tidal Fluctuations in Base Wells

The high permeability of the basal aquifer and its connection to the ocean is confirmed by the observed tidal fluctuations in the area of the Base supply wells. Figure 3-13 shows hydrographs of Base Wells 1 and 3 as well as the tidal stage during the period July 1 through July 10, 2004. Although the groundwater levels in the Base wells were affected by other factors, probably changes in the pumping pattern, groundwater level fluctuations with a period of about 6 hours and an amplitude of 2 to 2.5 cm are clearly visible in the hydrographs. The tidal stages have a period of about 6 hours and an

amplitude of about 60 cm. In other words, the fluctuations in groundwater levels in wells 1 and 3 are significantly damped with respect to the tidal fluctuations. It is also apparent that the timing of the peaks in groundwater levels lag the peaks in the tidal stage by about 5 to 6 hours. The observed tidal fluctuation in these wells was used to help calibrate the groundwater flow model as discussed in Section 5.

3.3.2.3 Water Quality

In many areas, the basal aquifer has groundwater with elevated salt content. Table 3-3 is a compilation of water samples taken from the basal aquifer in the Lajes area.

TABLE 3-3
Basal Aquifer

Constituent	Average	Maximum	Minimum	Number of Samples
Na	152.7	161	147	12
K	11.9	15.6	8.7	12
Mg	26	27.5	24.2	12
Ca	25.4	26.3	24.7	12
Cl	287.9	301.94	278.6	12
N	8.3	14.5	3.5	12
Si	53.9	58.3	51.5	12

3.3.3 Perched Aquifers

The occurrence of low permeability layers between the lava flows and pyroclastics can reduce vertical permeability. If these low permeability layers are extensive, they cause the existence of small-scale perched aquifers.

In the Lajes graben region 4 perched aquifers were identified (Rodrigues 2002): the Amoreiras; the Lajes 1; the Lajes 2 and the Fontinhas perched aquifers.

The Amoreiras perched aquifer is located in the top of Serra de Santiago. Discharges to Baia do Zimbral (diffuse springs), with a flow less than 1 l/sec.

The Lajes 1 perched aquifer is the highest of Lajes graben floor. Its principal known point of discharge discharge is the Caldeira Spring, with an average flow of 0.1 l/sec. Hydrogeologicaly this aquifer occurs between Lajes Ignimbrites formation and a continuous paleosol, and is cut by several faults. Groundwater levels in the Lajes 1 aquifer occur between 36.7 and 56.6 m sea level.

The Lajes 2 perched aquifer is only known in the northwest area of Lajes graben floor. This water table has an average altitude of 21.5 m (Rodrigues, 1993). The Lajes 2 aquifer occurs in the base of a lava flow that overlies a weathered ash layer.

According to Menezes (1993) this aquifer is responsible for small springs that occur at Vila Nova. This hypothesis seems valid because the perched aquifer tapped by well T-1112 in this village has a similar water level at 26.7 m. The Fontinhas aquifer is a high-level perched water body near the Fontinhas Fault, with an average water table altitude of 115 m. It is developed between a trachybasalt lava flow and weathered and compacted ash level.

The groundwater levels measured in various areas of the Lajes graben are presented in Figures 3-14. In most areas, the water levels in the perched aquifers are much higher than the water levels in the basal aquifer. However, in the Paul area, the perched aquifer is only slightly different than the basal aquifer. In this area, which is near the coast, the basal aquifers and perched aquifers may actually merge.

3.3.3.1 Aquifer Properties

No aquifer testing of well yield testing is available for any of the perched aquifers.

3.3.3.2 Water Quality

The water quality in the perched aquifer is generally better in terms of salt concentration than wells in the basal aquifer. Electrical conductivities measured in the perched aquifer wells are shown on Figure 3-14. Table 3-4 is a compilation of water quality samples from the perched aquifer in the Lajes area.

TABLE 3-4
Perched Aquifer

Constituent	Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	Number of Samples
Na	31.4	34.7	28	46
K	5.6	7.7	3.9	46
Mg	4.5	7.6	2.5	46
Ca	6.5	10.4	1.8	46
Cl	30.4	36	24.4	46
N	10.7	25.2	2.3	46
Si	48.8	45.2	53.7	46

In general, there is a correlation between the elevation on the water table and the water quality in the perched aquifer. Figure 3-15 is a plot of measured electrical conductivity in the canvassed wells in Lajes graben. This figure shows that water with lower electrical conductivity occurs at higher levels in the Lajes graben area. The figure also shows that the basal aquifer has the worse water quality, with respect to electrical conductivity, than the perched aquifer.

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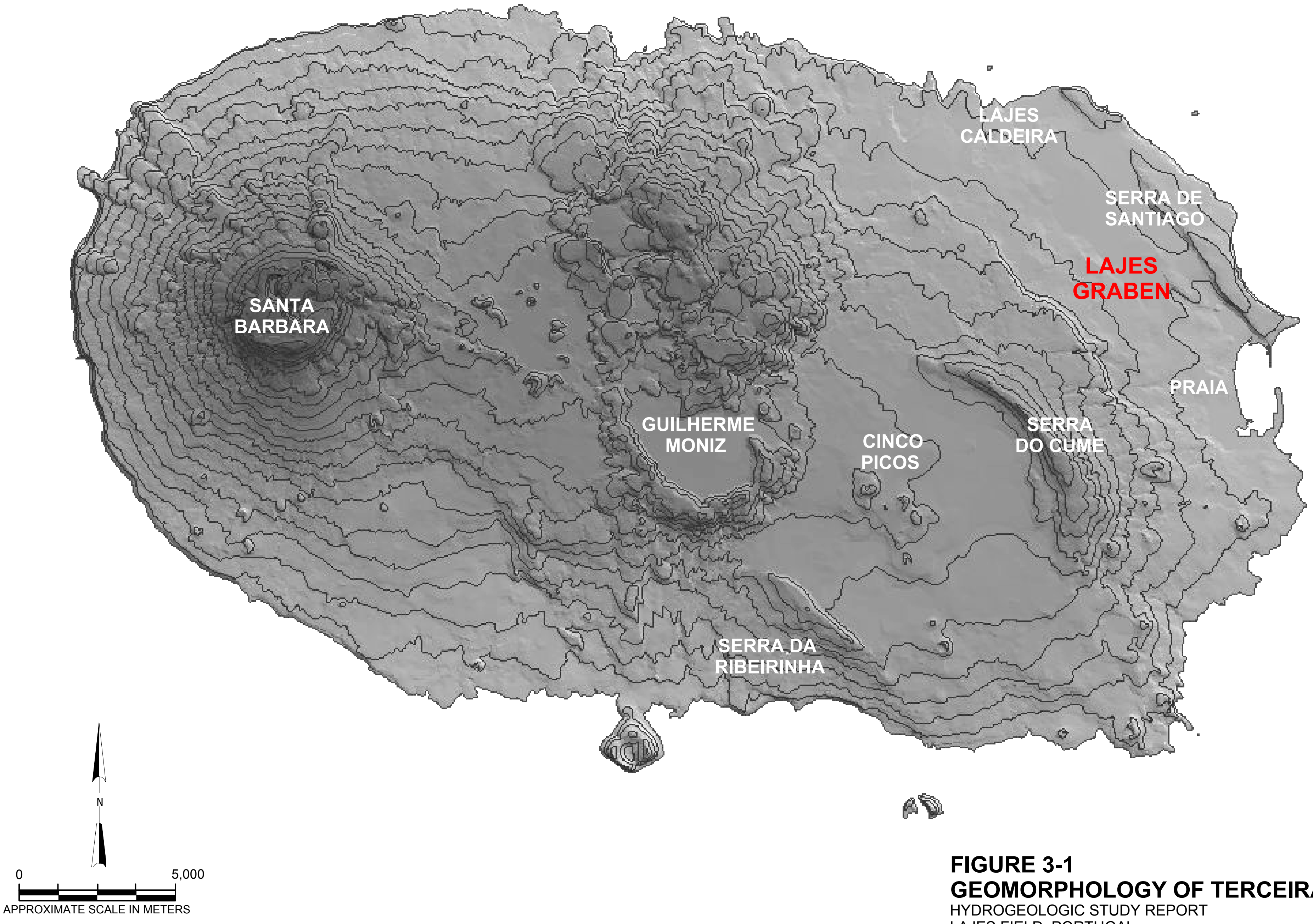

FIGURE 3-1
GEOMORPHOLOGY OF TERCEIRA ISLAND
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

CH2MHILL

ODIN/PROJ/AFCEE/181081_LAJES/FIGURES/SURFER/181081-109.SRF

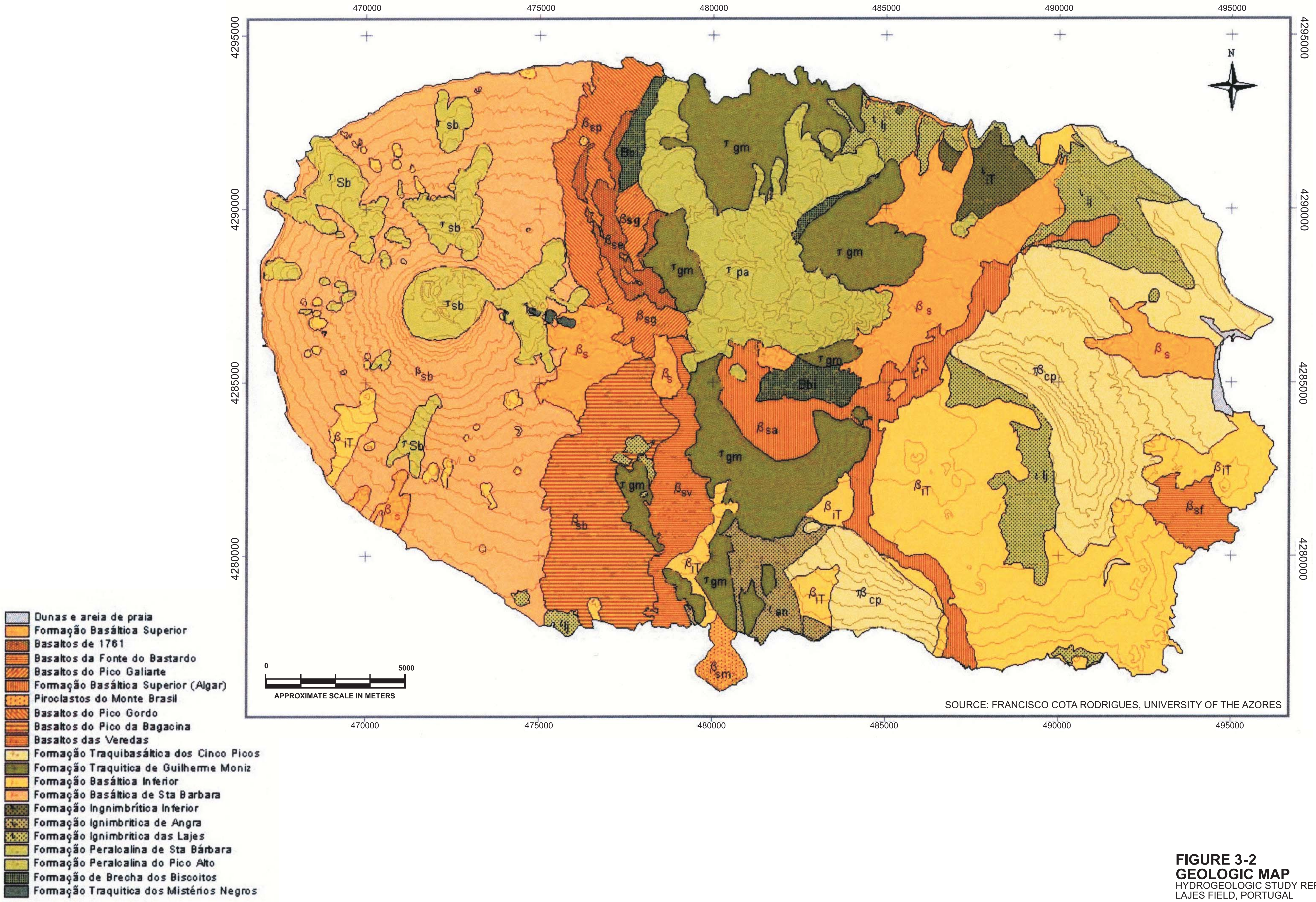

FIGURE 3-2
GEOLOGIC MAP
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

CH2MHILL

RDD \\ODIN\PROJ\AFCEE\181081_LAJES\FIGURES\FREEHAND\181801-303.FH10

LAJES IGNIMBRITES WITH SANTIAGO FAULT

PROBABLE PERCHING LAYERS AND UNDERLAYING TRACHYBASALT

NOTE:

PHOTOGRAPHS TAKEN ON THE SHORE BEYOND NORTHWEST END OF LAJES FIELD.

FIGURE 3-3
PHOTOGRAPHS OF LAJES IGNIMBRITES, PROBABLE PERCHING LAYERS, AND UNDERLAYING TRACHYBASALT
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

CH2MHILL

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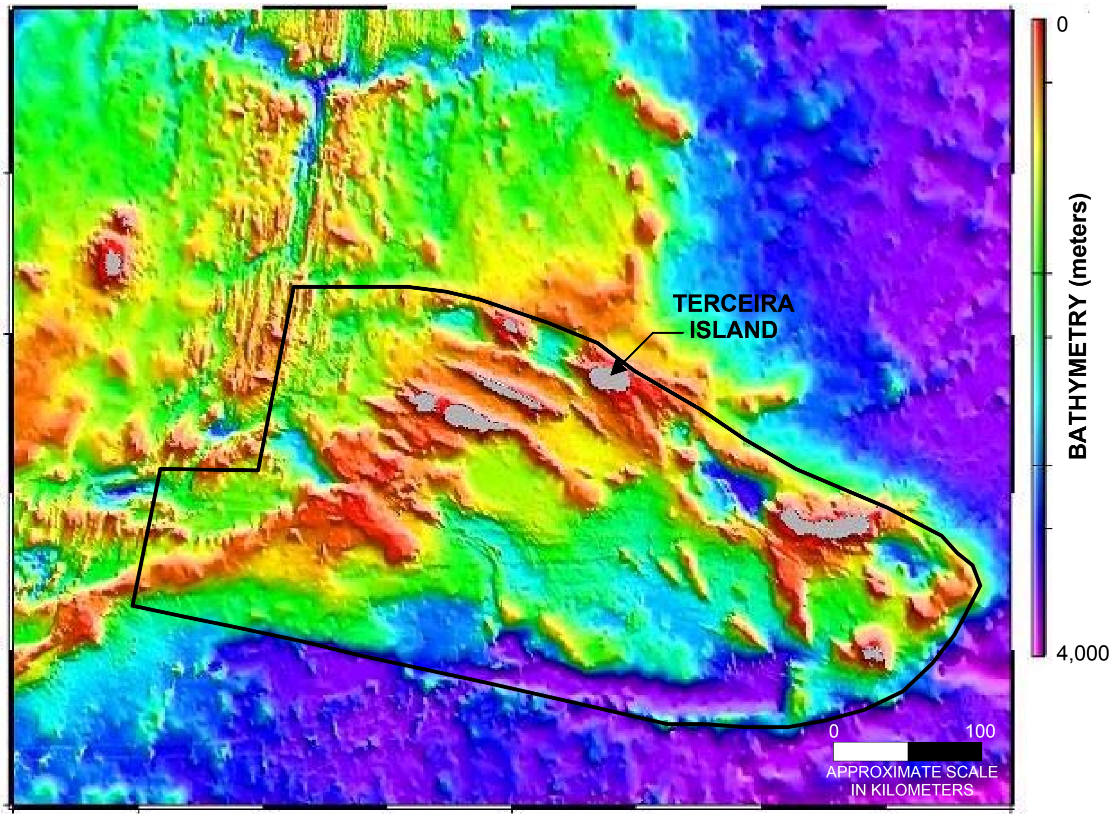
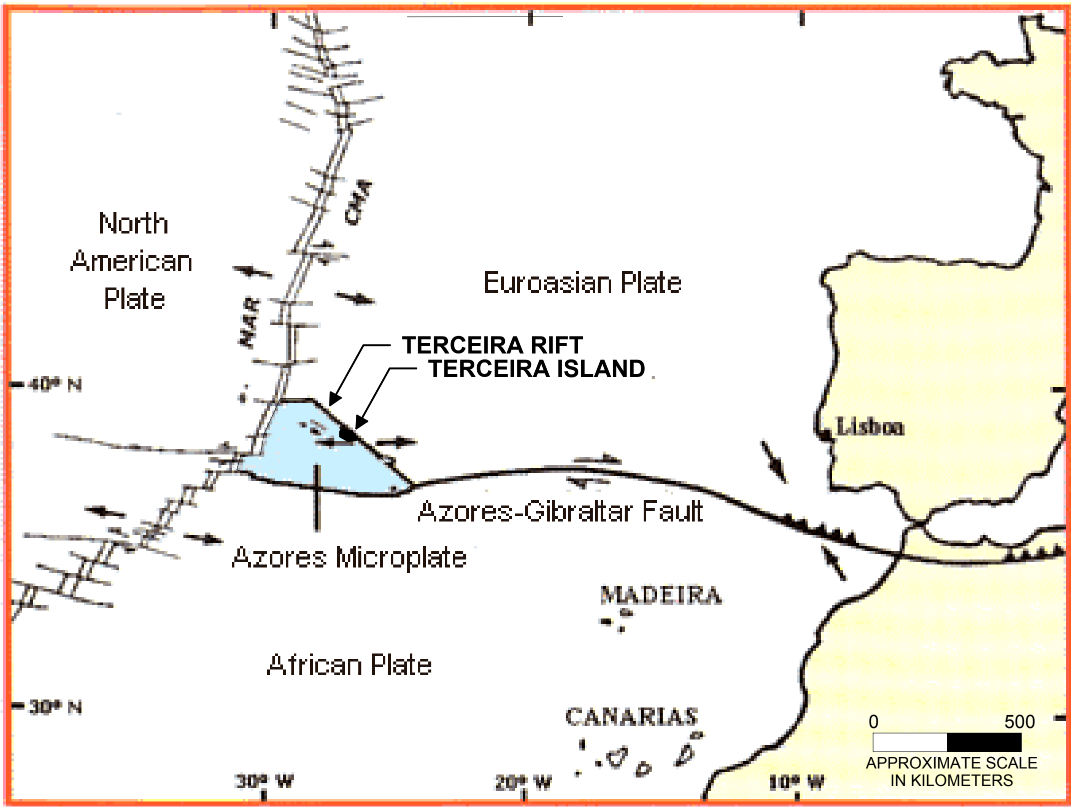


BATHYMETRY OF THE MID ATLANTIC RIDGE AND THE AZORES MICROPLATE



LOCATION OF AZORES MICROPLATE

FIGURE 3-4
AZORES MICROPLATE
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SOURCE: RODRIGUES, 1993

FIGURE 3-5
THE MAIN FAULTS OF TERCEIRA ISLAND AND LAJES GRABEN
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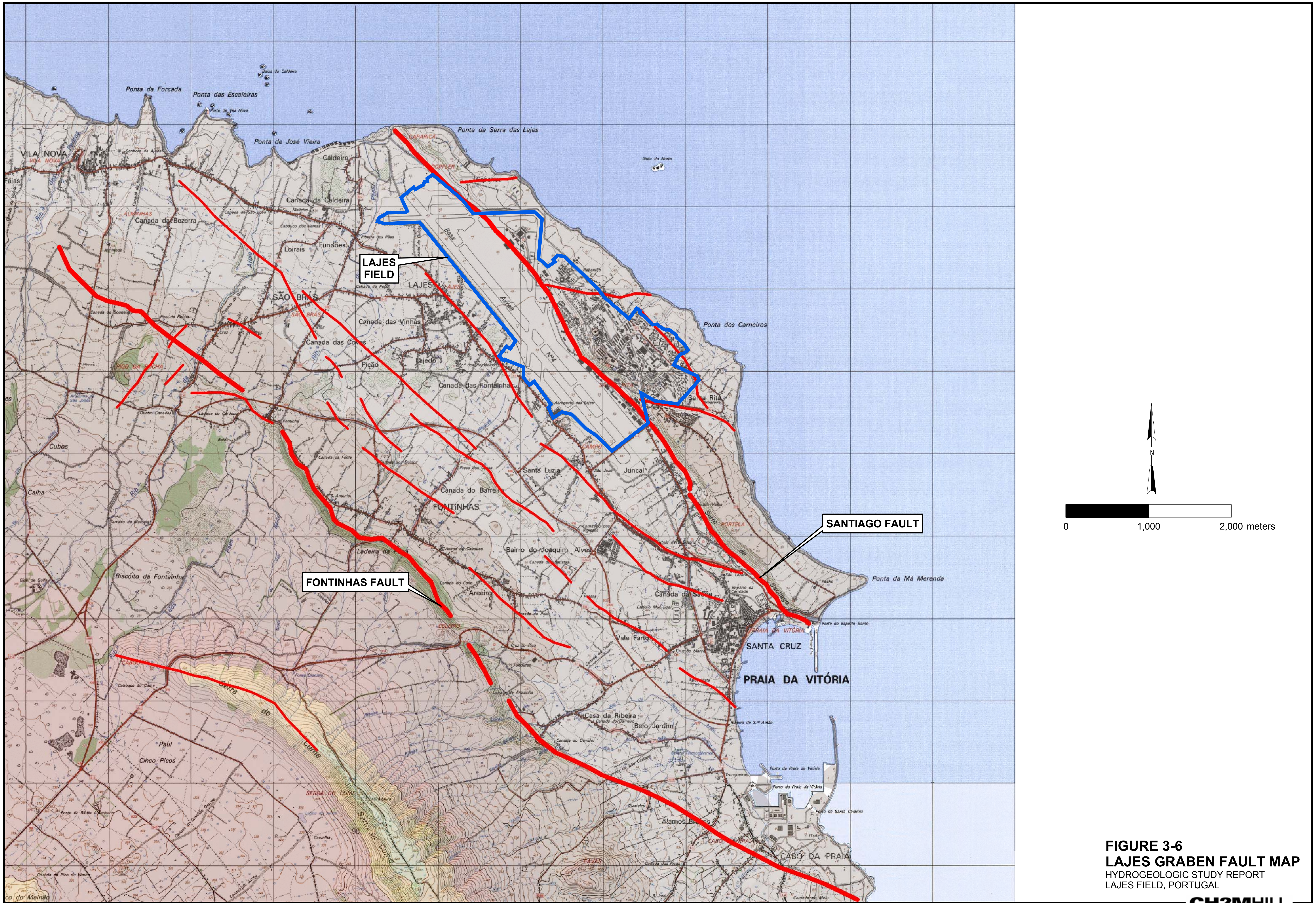

FIGURE 3-6
LAJES GRABEN FAULT MAP
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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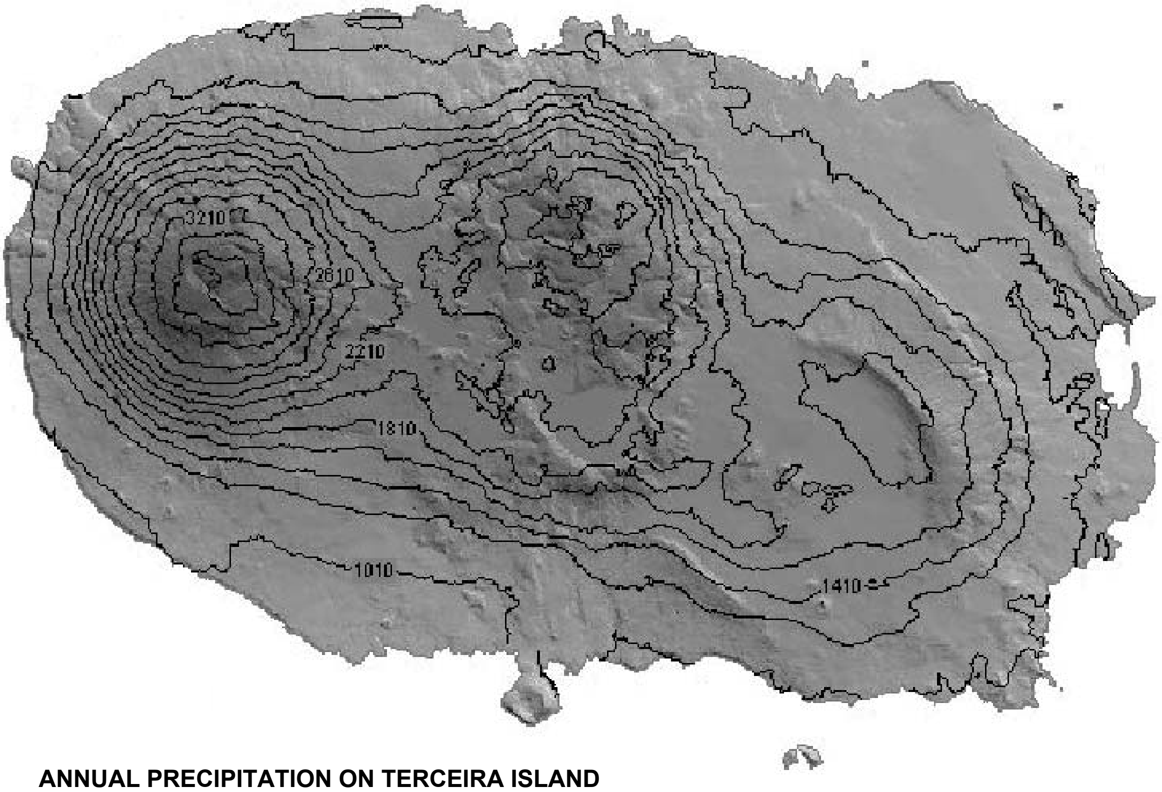
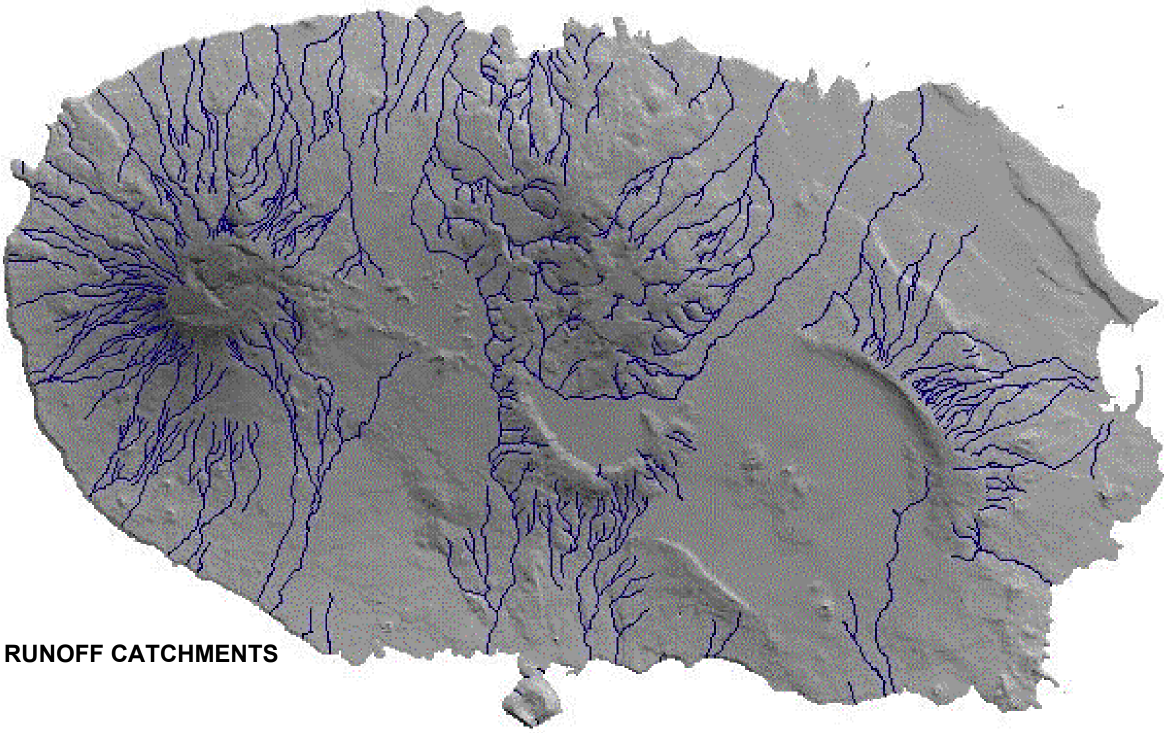


ANNUAL PRECIPITATION ON TERCEIRA ISLAND
SIMULATED BY THE CIELO MODEL DEVELOPED BY AZEVEDO (1996)



MAIN RUNOFF CATCHMENTS

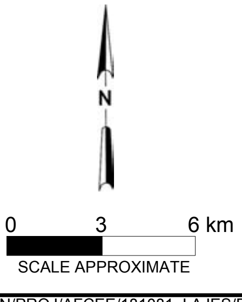


FIGURE 3-7
PRECIPITATION AND RUNOFF PATTERNS, TERCEIRA ISLAND

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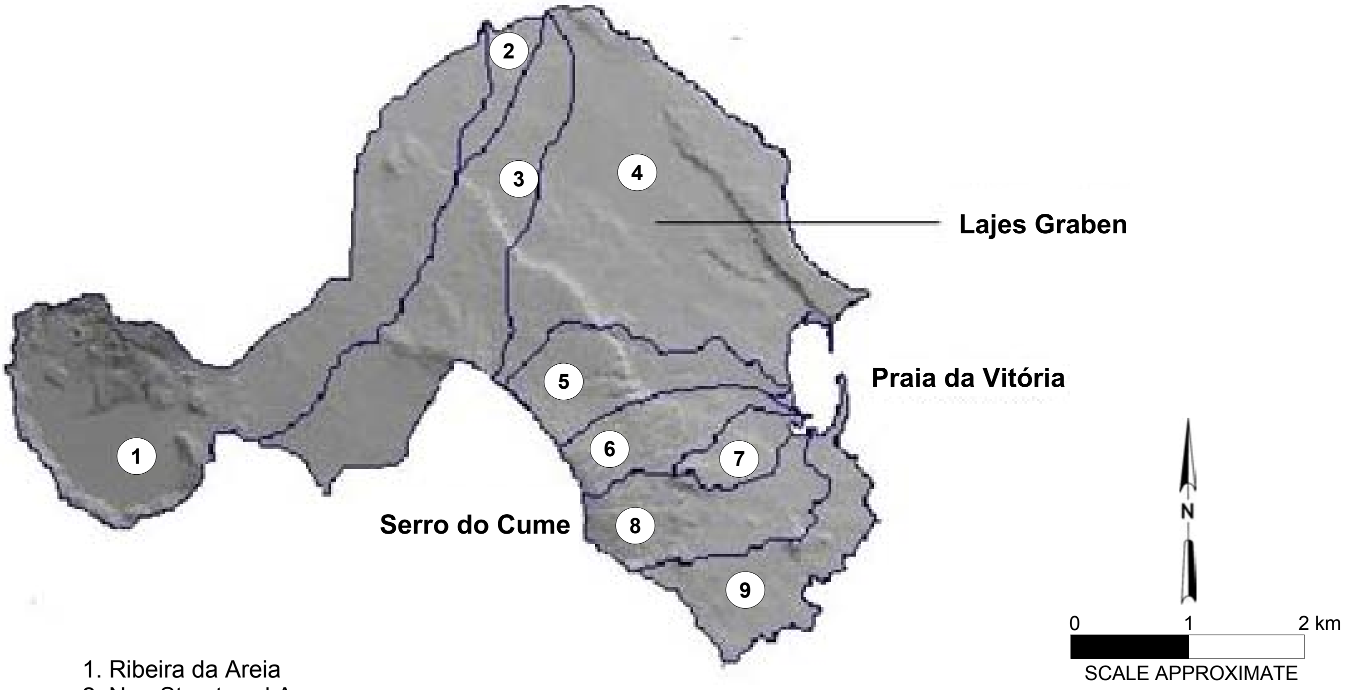
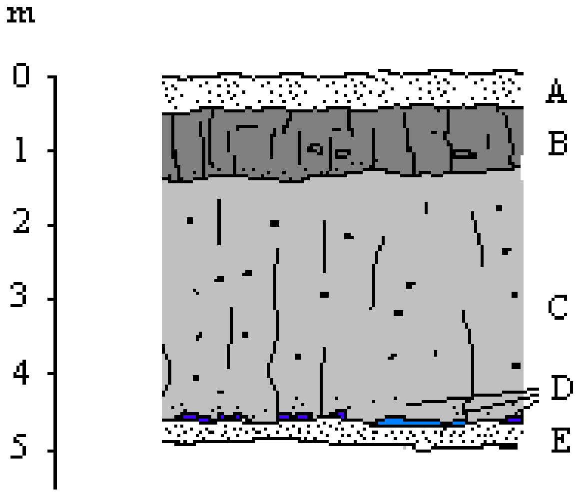
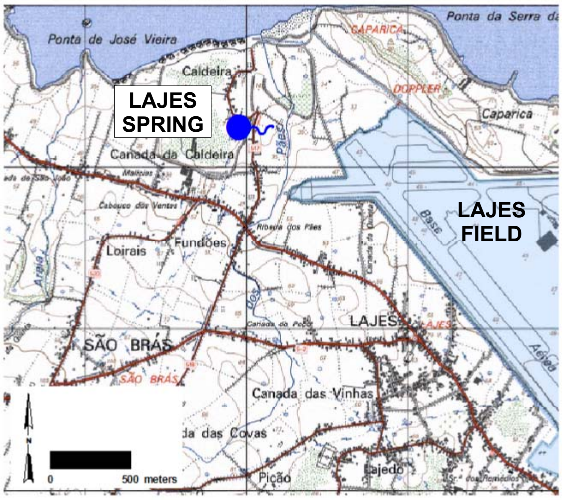


1. Ribeira da Areia
2. Non Structured Area
3. Ribeira dos Pães
4. Non Structured Area
5. Ribeira de Santo Antão
6. Ribeira do Belo Jardim
7. Ribeira do Tapete
8. Ribeira de Santa Catarina
9. Non Structured Area

FIGURE 3-8
HYDROLOGIC CATCHMENT AREAS OF THE LAJES GRABEN AREA
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL



A Soil
B Basaltic Flow
C Lajes Ignimbrites
D Springs
E Paleosol



LOOKING SOUTH AT THE FOUNTAIN AND SOURCE OF LAJES SPRING

FIGURE 3-9
GEOLOGIC SCHEME OF CALDEIRA DAS LAJES SPRING
HYDROGEOLOGIC STUDY REPORT
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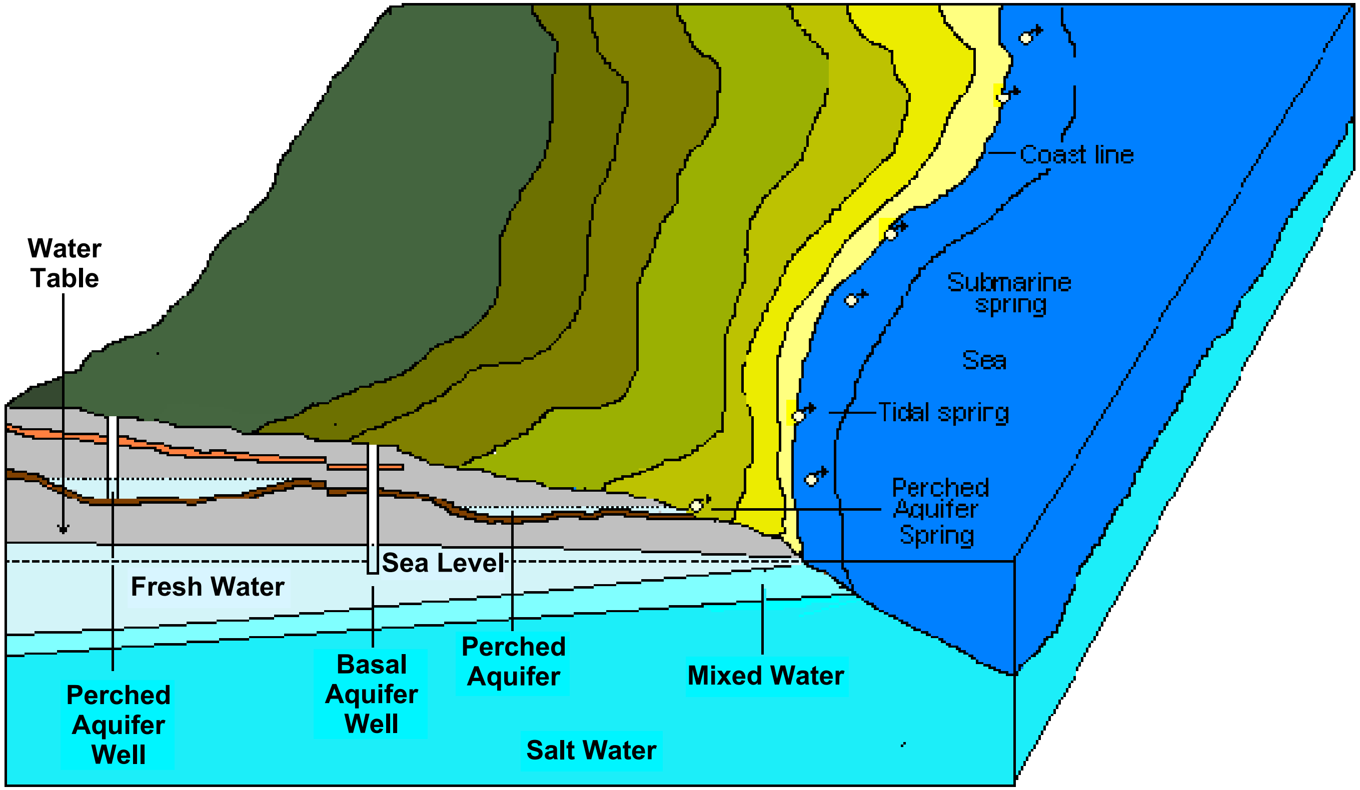

FIGURE 3-10
SCHEMATIC CROSS SECTION OF
LAJES GRABEN WITH AQUIFER SYSTEM
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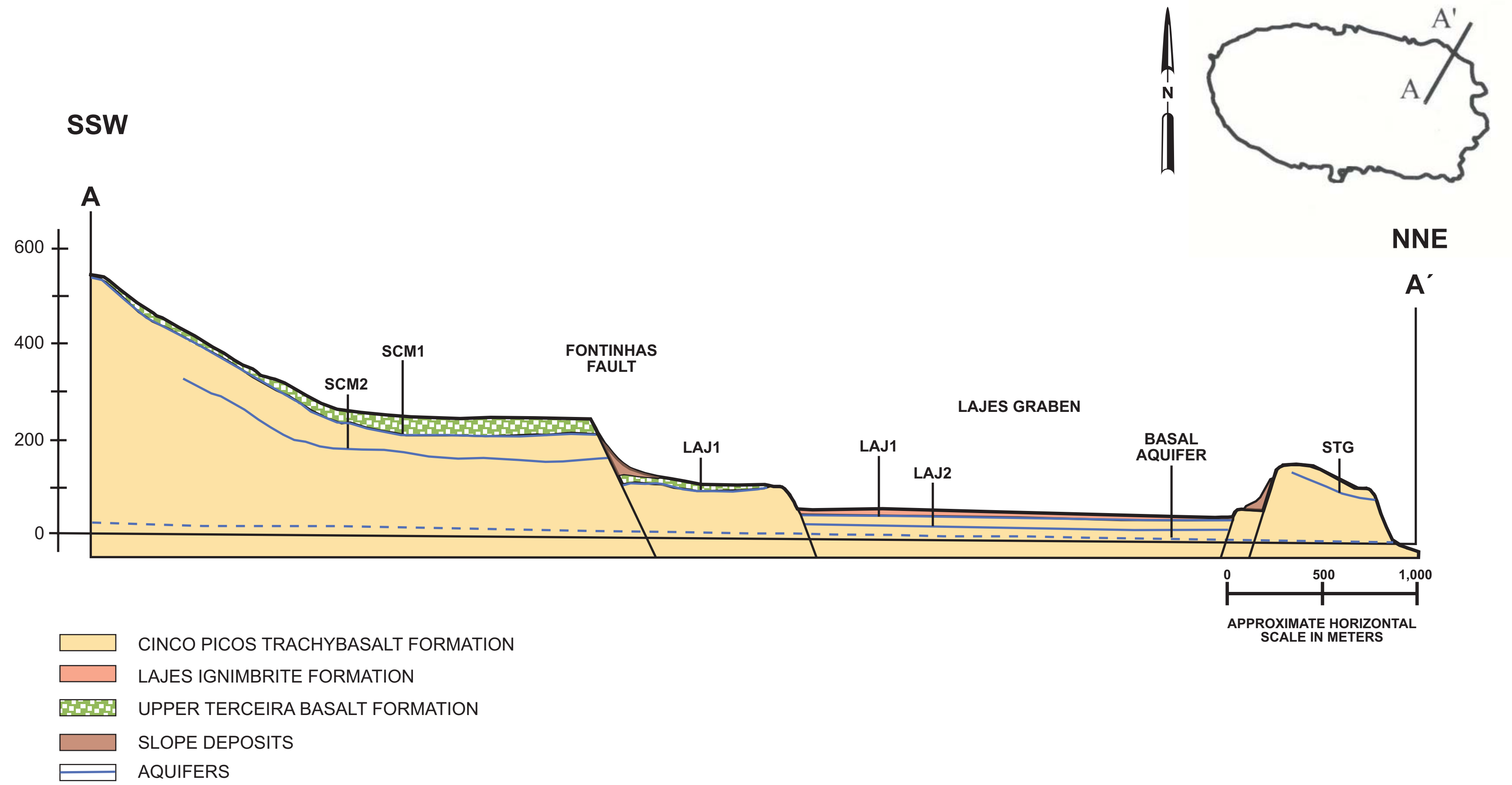

NOTE:

SCM1, SCM2, LAJ1, LAJ2, AND STG ALL REFER TO PERCHED AQUIFERS.

FIGURE 3-11
CROSS SECTION THROUGH LAJES GRABEN (SOUTH TO NORTH)
HYDROGEOLOGIC STUDY REPORT
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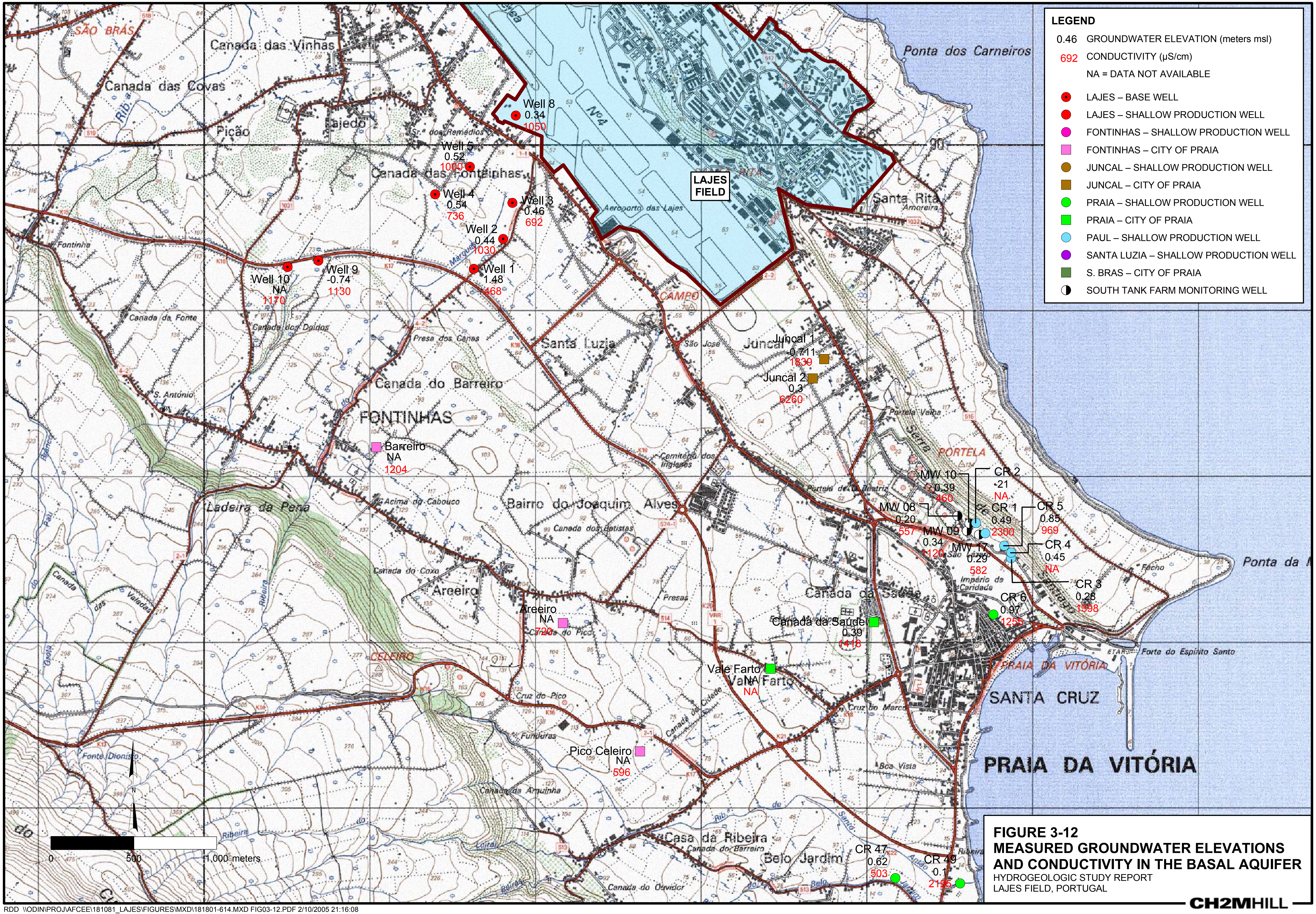

FIGURE 3-12
MEASURED GROUNDWATER ELEVATIONS AND CONDUCTIVITY IN THE BASAL AQUIFER
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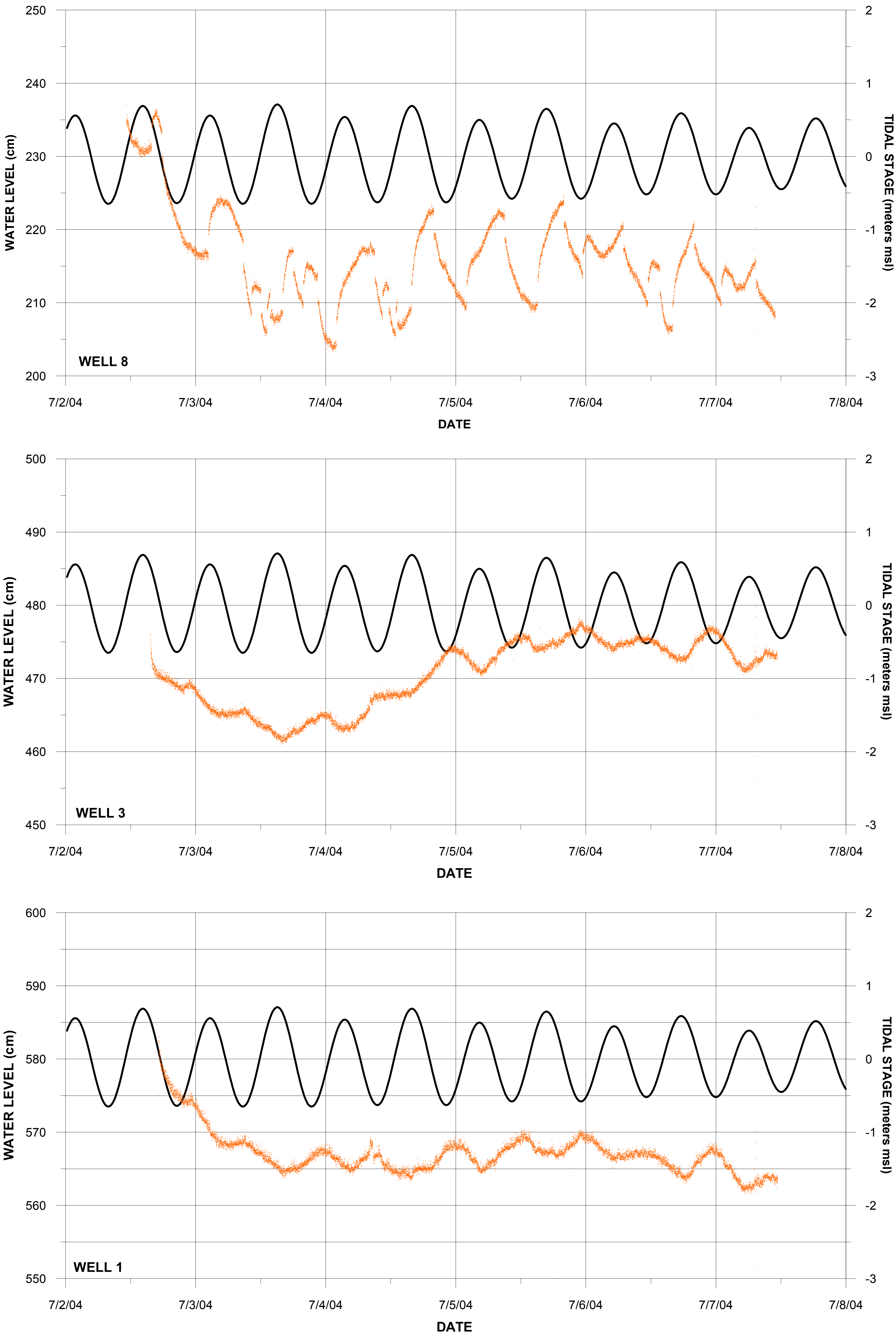

TIDES

WATER LEVELS (AFTER BAROMETRIC CORRECTION)

FIGURE 3-13
GRAPH OF GROUNDWATER LEVELS AND TIDAL STAGE IN WELL 1, WELL 3, AND WELL 8 – JULY 2004
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LAJES FIELD, PORTUGAL

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FIGURE 3-14
MEASURED GROUNDWATER ELEVATIONS AND CONDUCTIVITY IN THE PERCHED AQUIFER
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

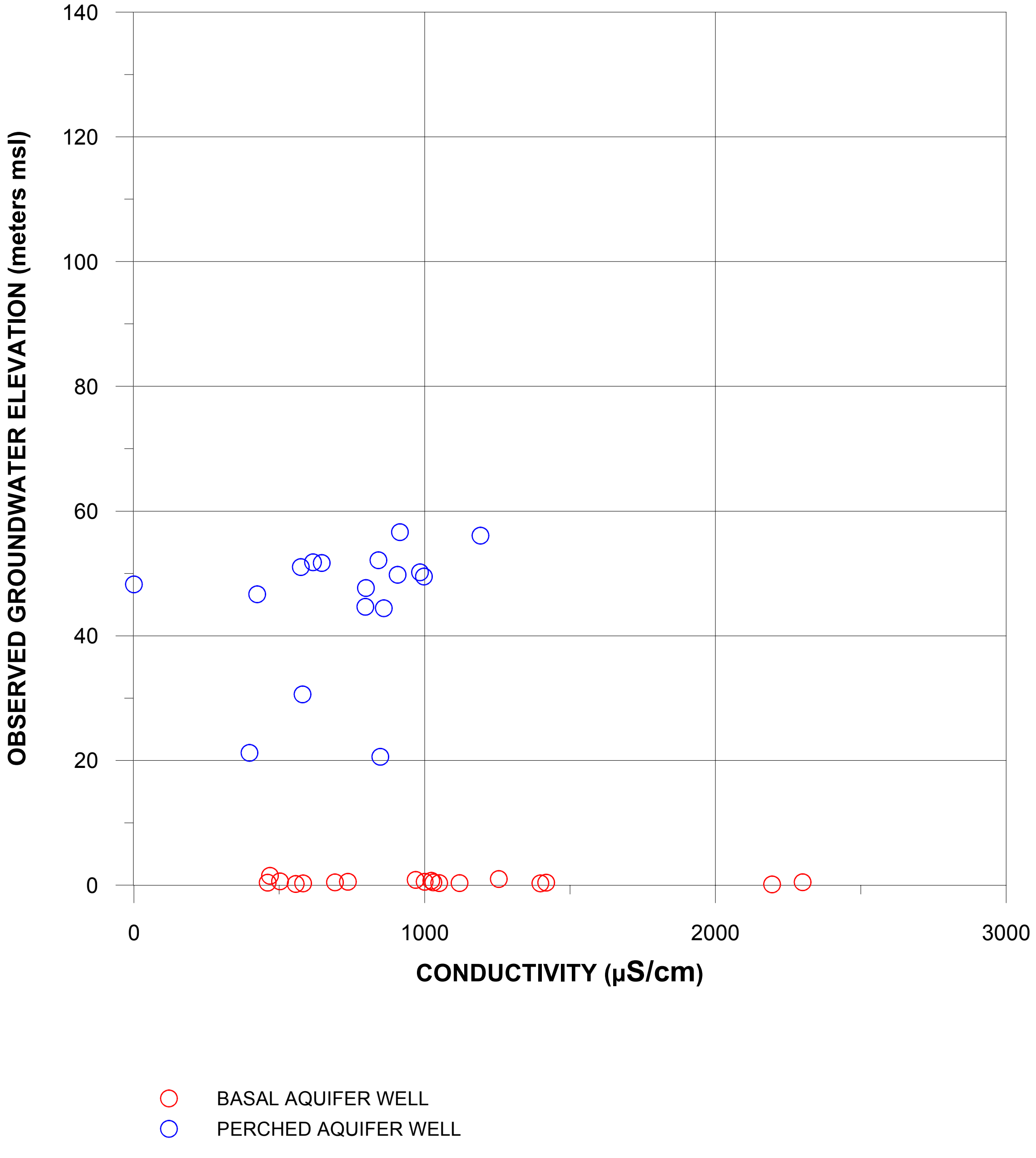

FIGURE 3-15
CONDUCTIVITY VERSUS GROUNDWATER LEVEL FOR ALL WELLS
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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SECTION 4.0

Groundwater Supply

4.1 Overview of Base Water Supply

4.1.1 Base Well Field

Lajes Field currently obtains its water supply from a network of production wells that tap the basal aquifer. The locations of these wells are shown on Figure 2-1. The average amount of pumping from the Base wells is about 0.54 MGD (2045 m3/d) (MWH, 2003). The yield from each well in the well field is presented in Table 4-1 below:

TABLE 4-1
Base Well Pumping Summary and Well Capacity

	Capacity (gpm)	Average Q (gpm)	Average Q (m^3/d)
Well_1	0	0	0
Well_2	290	43	302
Well_3	320	52	333
Well_4	300	46	313
Well_5	275	39	287
Well_8	293	44	305
Well_9	245	31	255
Well_10	240	29	250
Total	1,963	283	2,046

4.1.1.1 Groundwater Levels

Static groundwater levels in the Base wells were measured during the well canvass and also during field work in early July, 2004. These data are plotted on Figure 3-12. These data show that the groundwater levels are near sea level. The measured water levels in Well 1 and in Well 9 appear to be anomalous and possibly in error. The average static groundwater level in the other five wells is +0.46 meters.

A discussion of the tidal fluctuations measured in the Base wells was included in Section 3. Tidal fluctuations on the order of 4 to 6 cm over a tidal cycle were observed during July 2004.

4.1.1.2 Water Quality

The Base well field skims fresh groundwater from the lens of fresh groundwater “floating” atop the salt water that underlies the basal aquifer throughout the Lajes graben. The Ghyben Herzberg approximation states that the base of fresh water should occur at a depth 40 times the elevation of the water table. Based on the average head in the Base wells field, this means that the base of fresh water should lie at a depth approximately 19 m below the water table. Two lines of evidence support this estimate of the depth to the freshwater interface.

seawater occurred at –10.5 to –19.4 m msl. In the vicinity of Well 9 the base of fresh water occurs at –15 to –25 m msl. In the vicinity of Well 10, the base of fresh water occurs at -12 to –30 m msl.

The second line of evidence is based on direct measurement of the fresh water-salt water interface in Base Well 1. During July 2004, a Solinst temperature and conductivity probe was lowered slowly in the well and then withdrawn slowly from the well. Care was taken to avoid disturbing the stratification of water quality in the well. The results of this survey are presented in Figure 4-1. This figure clearly shows that the base of fresh water occurs at a depth of 16 to 18 m below the water table. It also shows that the interface may have been disturbed by the probe because the conductivity measured in the "up" part of the chart was typically higher than in the "down" part of the chart. This type of survey was attempted in Base Well 3 and Base Well 8. Data from this survey is also presented in Figure 4-1. Unfortunately,the well depth, prevented lowering the probe deeper than about 4 to 7 meters into the basal aquifer. The salt water interface was not detected in either of these wells although a trend on increasing salinity with depth was observed in Well 8.

4.1.2 Recommendations

4.1.2.1 Improve Access to the Well Casing for Each of the Base Wells

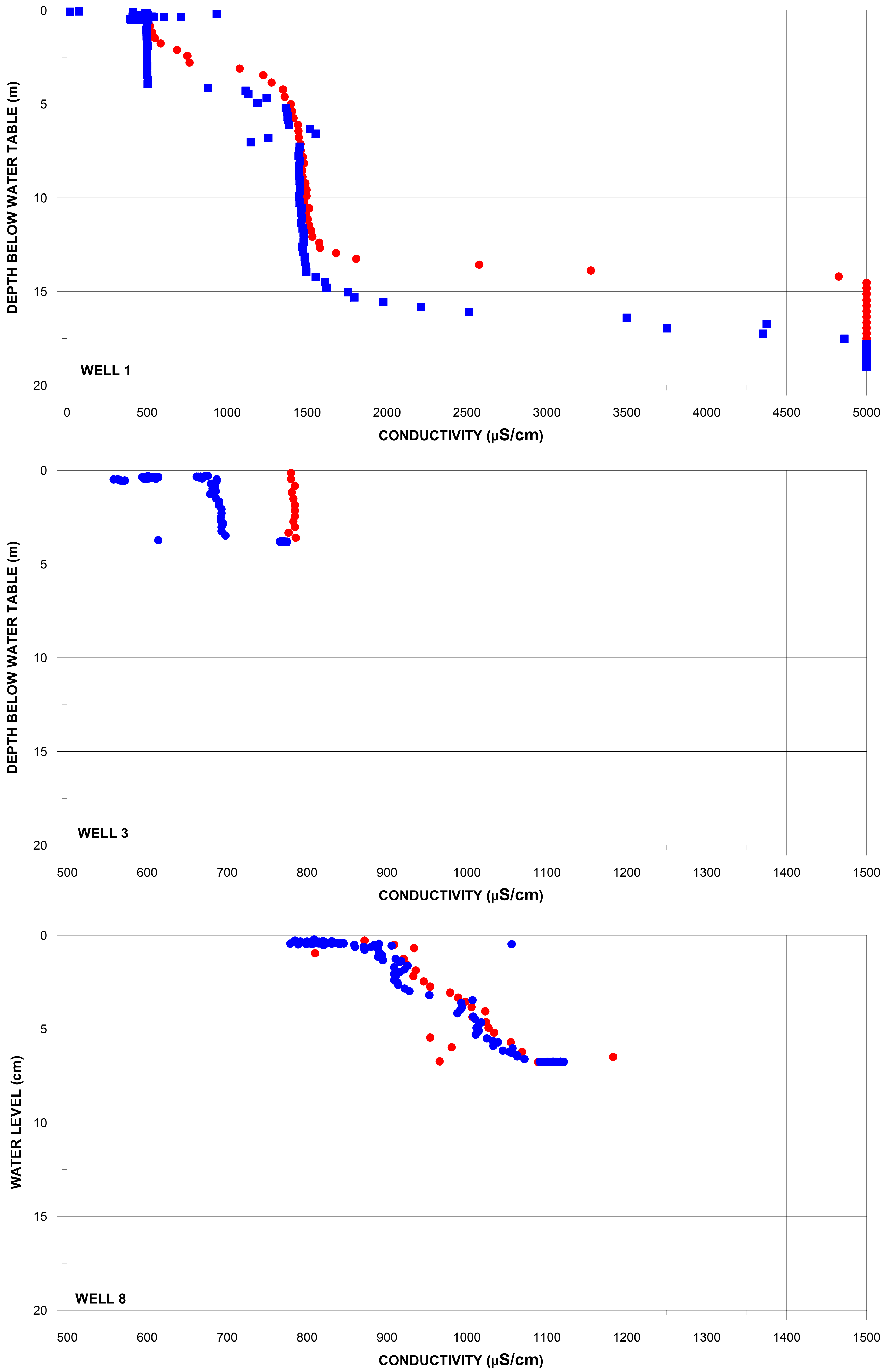
Groundwater levels in the Base wells are difficult to measure because of obstructions at the top of the well and within the well casing itself. Monitoring of groundwater levels in the Base wells should be performed frequently. In addition, with improved access, the depth to the salt water interface should be monitored frequently to avoid upconing of salt water into the well.

4.1.2.2 Evaluate the Potential for Upconing of Salt Water at Each Well in the Well Field

After access to the well casing is improved, the potential for upconing of salt water due to over pumping of the well should be conducted. Measurements of the position of the salt water interface should be done for both pumping and non-pumping conditions. The field data should be used to perform a theoretical analysis of the potential for upconing under several different assumptions of well pumping rate, duration of pumping and depth of the well intake.

4.1.2.3 Recommend Improvements to Operation of the Base Well Field

Based on the results of the upconing analysis, recommendation for the operation and monitoring of the Base well field should be developed. These would include recommendations on pumping rate and duration, placement of the pump, frequency of monitoring and techniques of monitoring.



PROBE MOVING UP
PROBE MOVING DOWN

FIGURE 4-1
DEPTH DISTRIBUTION OF CONDUCTIVITY IN WELL 1, WELL 3, AND WELL 8
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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SECTION 5.0

Groundwater Model

5.1 Model Overview

A finite element groundwater flow model of the Lajes graben area was developed to help integrate the existing hydrogeologic data, to help focus drilling targets at suspected sources of contamination, and to provide a framework for interpreting future hydrogeologic information that will be collected during future site investigations.

5.1.1 Software

The model code used for the model is Microfem, a finite element groundwater flow modeling code developed in the Netherlands. Microfem (http://www.microfem.com/), as currently configured, has the capacity of up to 250,000 nodes and 25 model layers. Microfem is a very flexible code that can easily accept complex geometry, such as faulting, into the finite element mesh. Microfem has been used to develop groundwater flow models at both Aviano AB and Incirlik AB.

5.1.2 Model Grid

The finite element grid for the model is shown on Figure 5-1. The model grid consists of 50072 nodes, 99751 elements and covers an area of 26379 hectares. The model covers the area on land that is believed to contribute water to the Lajes graben aquifers. The model area also extends approximately 5 km beyond the shoreline.

5.1.3 Model Layering

The model consists of three layers. Figure 5-2 gives a schematic representation of model layering. The upper model layer comprises the perched aquifer system. The lower two layers comprise the basal aquifer system. The vadose zone that separates the perched aquifer from the basal aquifer is modeled as an aquitard with appropriately low vertical permeability to match the observed groundwater levels in the perched aquifer. The base of the model is the assumed base of fresh water.

5.1.4 Aquifer Properties

5.1.4.1 Basal Aquifer

The hydraulic conductivity of the basal aquifer was assumed to be 1000 m/d. Based on model calibration results, the typical thickness of the basal aquifer, at least in the Base well field area, is assumed to be 14 m. This means that the transmissivity of the basal aquifer is 14,000 m^2/d. In the model, it was assumed that the transmissivity of the basal aquifer is a constant 14,000 m^2/d throughout the model area.

5.1.4.2 Perched Aquifer

No aquifer testing has been performed on the perched aquifer. However, it is known that the yield of perched aquifer wells is low, suggesting that the hydraulic conductivity and transmissivity of the perched aquifer is low. In the groundwater flow model, it is assumed that the transmissivity of the perched aquifer is 10 m^2/d throughout the model area.

5.1.4.3 Perching Layer(s)

The perched aquifer is caused by the presence of low permeability strata that occur between the base of the perched aquifer and the basal aquifer. However, there is no quantitative information available on the actual properties of the perching layer(s). The model was run repeatedly while adjusting the vertical permeability of the perching layer until a reasonable match between the observed and simulated water levels in the perched aquifer was achieved. Although this value varies from place to place, a typical value of the vertical hydraulic conductivity of the perching layer is 5×10^{-4} m/d or about 6×10^{-7} cm/sec. It should be remembered that because much of these materials that occur between the perched aquifer and the basal aquifer are unsaturated, the hydraulic conductivity values stated above are unsaturated hydraulic conductivities at the ambient moisture conditions in the vadose zone. The unsaturated hydraulic conductivity of a material is always less than its saturated hydraulic conductivity.

5.1.4.4 Faults

The numerous faults that occur in the model area are believed to affect groundwater in the perched aquifers but not the basal aquifer. Because it is likely that the faults offset the thin perching layers, it is likely that the faults act as barriers to groundwater flow. Therefore, in the model, the faults are input as barriers to lateral flow in the perched aquifer but are assumed to have no effect on the basal aquifer.

5.1.5 Model Boundary Conditions

Boundary conditions for the model included recharge from precipitation, infiltration of streamflow, consumption of groundwater by evapotranspiration in high groundwater areas, discharge to springs and seeps, pumping for water supply, and discharge to the Atlantic Ocean.

5.1.5.1 Recharge and Discharge

The principal source of recharge to the model is the average annual recharge from precipitation of 272 mm. It is also assumed that some focused recharge occurs near the Fontinhas fault that causes the elevated groundwater levels seen in perched aquifer wells in that area.

The model includes discharge of groundwater by consumption of vegetation in areas of high groundwater levels. The model assumes that the maximum rate of evapotranspiration is 250 mm/year, but this rate would decline linearly until it becomes zero where the water table is greater than 2 m below the land surface.

Direct discharge of groundwater to the land surface occurs when the water table is at or above the land surface.

Pumping from the Base water wells is included in the model at average rates shown in Table 5-1. Since no pumping information is available on the pumping rates from the City of Praia da Vitoria wells, these well were not included in the model.

TABLE 5-1
Pumping from Base Well Field (Source: Montgomery report)

	Average Q (gpm)	Average Q (m3/d)
Well 1	0	0
Well 2	43	302
Well 3	52	333
Well 4	46	313
Well 5	39	287
Well 8	44	305
Well 9	31	255
Well 10	29	250
Total		2,046

Most groundwater in the Lajes graben eventually discharges to the Atlantic Ocean. This is included in the model as fixed head nodes located in the offshore area. The value of the fixed head at the offshore area is based on the equivalent freshwater head that would be felt at the bottom of the seafloor in each model node. The equivalent freshwater head is computed by:

$$Hf = depth*(p-pf)/pf \tag{4}$$

Where:

Hf = equivalent freshwater head at seafloor at point of interest
Depth = depth of the ocean at the point of interest
P = density of sea water = 1.025
Pf = density of fresh water = 1

5.2 Model Calibration

Calibration of the groundwater flow model is a process of adjusting model parameters until a reasonable match between the observed and simulated calibration targets are achieved. A *calibration target* is a set of observed information that can be used to test the ability of the model to accurately simulate the observed data. There are five calibration targets available from calibrating the Lajes groundwater flow model. These are discussed below.

5.2.1 Calibration Targets

The four calibration targets are: observed groundwater levels in the basal aquifer, the observed groundwater levels in the perched aquifer, observed tidal fluctuations in the Base supply wells, and seasonal fluctuations in the perched aquifer.

5.2.1.1 Groundwater Levels in Basal Aquifer

The measured groundwater levels in the basal aquifer are shown on Figure 3-12. Figure 5-3 is a scattergram that shows the comparison between the observed and simulated groundwater levels in the basal aquifer. This scattergram shows a reasonable match between the observed and simulated groundwater levels in the Basal aquifer. The calibration statistics are: the mean error in heads is 0.013 m; the mean absolute error in heads is 0.2 m; the root mean squared error (RMS) is 0.27 m; the RMS divided by the range in water levels is 0.15.

5.2.1.2 Groundwater Levels in Perched Aquifer

The measured groundwater levels in the perched aquifer are shown on Figure 3-14. Figure 5-4 is a scattergram that shows the comparison between the observed and simulated groundwater levels in the perched aquifer. This scattergram shows a reasonable match between the observed and simulated groundwater levels in the Basal aquifer. The calibration statistics are: the mean error in heads is –3.88 m; the mean absolute error in heads is 4.55 m; the root mean squared error (RMS) is 6.11 m; the RMS divided by the range in water levels is 0.059.

5.2.1.3 Tidal Fluctuations in Base Supply Wells

During the period of July 1 through July 10, 2004, groundwater levels were monitored at 30 second intervals in Base Wells 1, 3 and 8. The data from Well 8 were “noisy” because that well was being pumped during this time. However, a good record of water level data from wells 1 and 3 was obtained. As discussed in Section 3.3.2.2, groundwater level fluctuations with a period of about 6 hours and an amplitude of 2 to 2.5 cm are clearly visible in the hydrographs. Although the groundwater levels in the Base wells were affected by other factors, probably changes in the pumping pattern, the tidal signature was used as a calibration target. The tidal stages have a period of about 6 hours and an amplitude of about 60 cm. In other words, the fluctuations in groundwater levels in Wells 1 and 3 are significantly damped with respect to the tidal fluctuations. It is also apparent that the timing of the peaks in groundwater levels lag the peaks in the tidal stage by about 5 to 6 hours.

Figure 5-5 show a comparison of observed and simulated groundwater levels when using the model to simulated tidal fluctuations. This figure shows that there is a good match between the observed and simulated groundwater levels.

5.2.1.4 Seasonal Fluctuations in Perched Aquifer

There are no hydrographs available for wells in the perched aquifer. However, discussions with a local expert (Dr. Francisco Cota Rodrigues) indicated that perched aquifer wells rise 1 to 2 meters during the rainy season but then fall quickly back to their normal level. The model was run in a transient mode to simulate the total annual recharge occurring within a three month period, assumed to be January through March. Figure 5-6 shows the results of that simulation. The simulated groundwater levels in several locations in the perched aquifer approximate the qualitative observations on the fluctuations on groundwater levels in the perched aquifer.

5.2.1.5 Summary of Calibration

Based on the comparison of observed and simulated groundwater levels and groundwater level changes, the Lajes graben groundwater flow model is believed to be reasonably well calibrated. However, it should be remembered that there are still limited data on the groundwater levels and aquifer properties in the Lajes graben. Therefore, the model, as it currently stands, should be viewed as an approximate representation of the groundwater flow system. The model is believed suitable for developing target drilling locations to begin assessing suspected sources of contamination. However, as additional data are collected, the model should be updated and recalibrated, especially in areas where detailed hydrogeologic data have become available.

5.3 Model Results

The calibrated groundwater flow model was run to illustrate several aspects of the groundwater flow system in Lajes graben

5.3.1 Groundwater Levels and Flow Directions in Basal Aquifer

Figure 5-7 shows the simulated average groundwater levels and the direction of groundwater flow in the basal aquifer as computed by the calibrated groundwater flow model. Figure 5-7 also shows approximate contours of groundwater elevation in the basal aquifer based on observed data. Because of sparse water level data in the basal aquifer, it was only possible to draw contours of observed groundwater levels in the area of the Base well field.

5.3.2 Groundwater Flow Direction in Perched Aquifer

Figure 5-8 shows the simulated average groundwater levels and the direction of groundwater flow in the perched aquifer as computed by the calibrated groundwater flow model. Figure 5-8 also shows approximate contours of groundwater elevation in the perched aquifer based on observed data. Note that although the simulated groundwater flow vectors show directions of groundwater movement, it should be remembered that most of the groundwater recharge actually moves vertically downward into the basal aquifer. Model simulations suggest that groundwater in the perched aquifer moves laterally only a few tens of meters before leaking downward in to the basal aquifer.

5.3.3 Source of Groundwater Pumped at the Base Well Field

Figure 5-9 shows the source of the groundwater that is being pumped by the Base Well Field. The potential source areas (DISCO sites) are also shown of Figure 5-9. The figure shows that the well field draws water from as much as 7 km upgradient of the well field. There is no indication that the Base well field could obtain any water from potentially contaminated areas onbase.

However, the abandoned Cabrito pipeline (DISCO Site 5013) is crossing the simulated source area for the Base well field and could impact the quality of water pumped from the Base wells. In addition, agricultural or other activities that occur within the capture zone of the Base well field could also impact the quality of water pumped from the Base wells.

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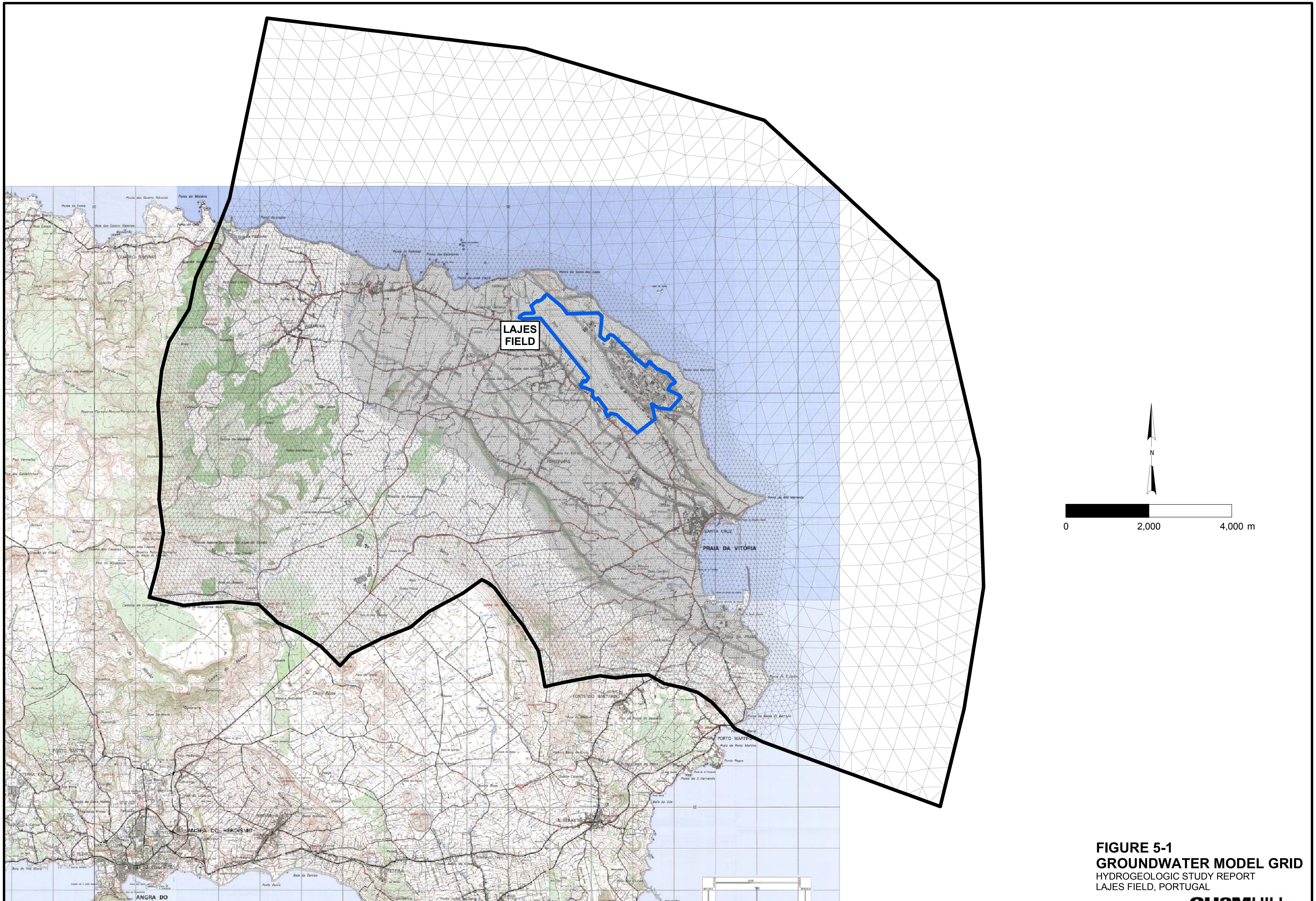

FIGURE 5-1
GROUNDWATER MODEL GRID
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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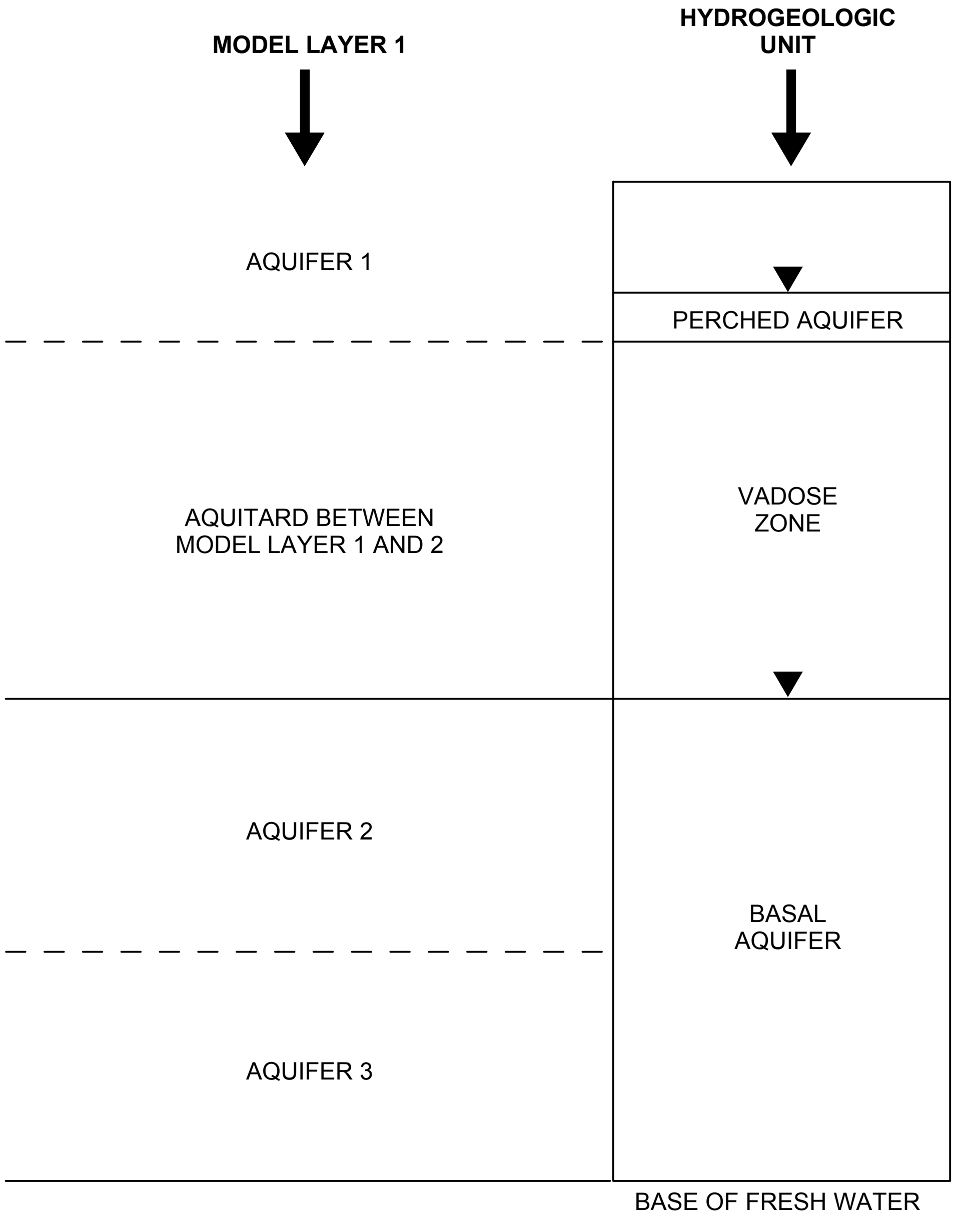

FIGURE 5-2
SCHEMATIC OF MODEL LAYERING
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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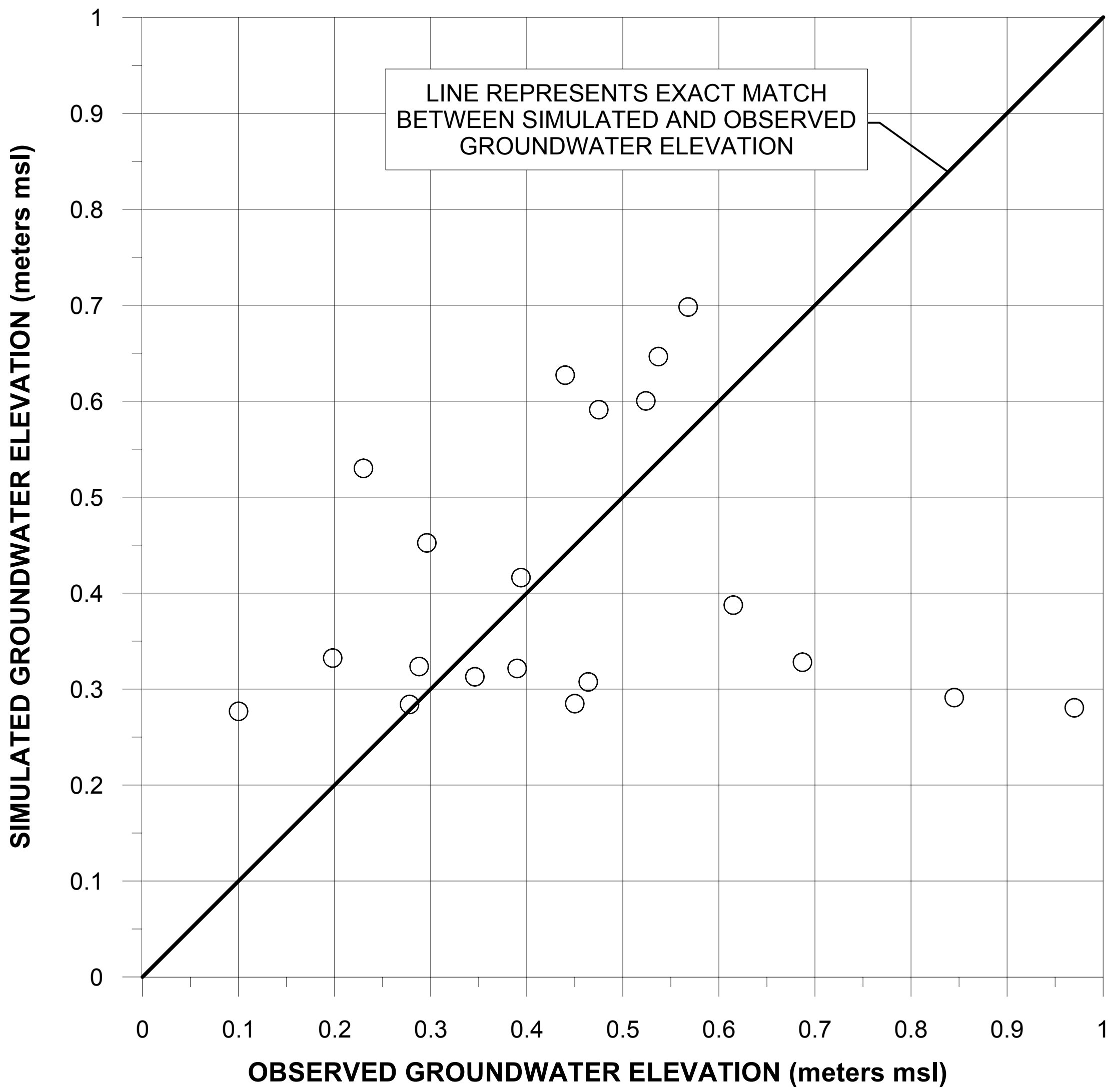

FIGURE 5-3
COMPARISON OF OBSERVED VERSUS SIMULATED GROUNDWATER LEVELS IN THE BASAL AQUIFER
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

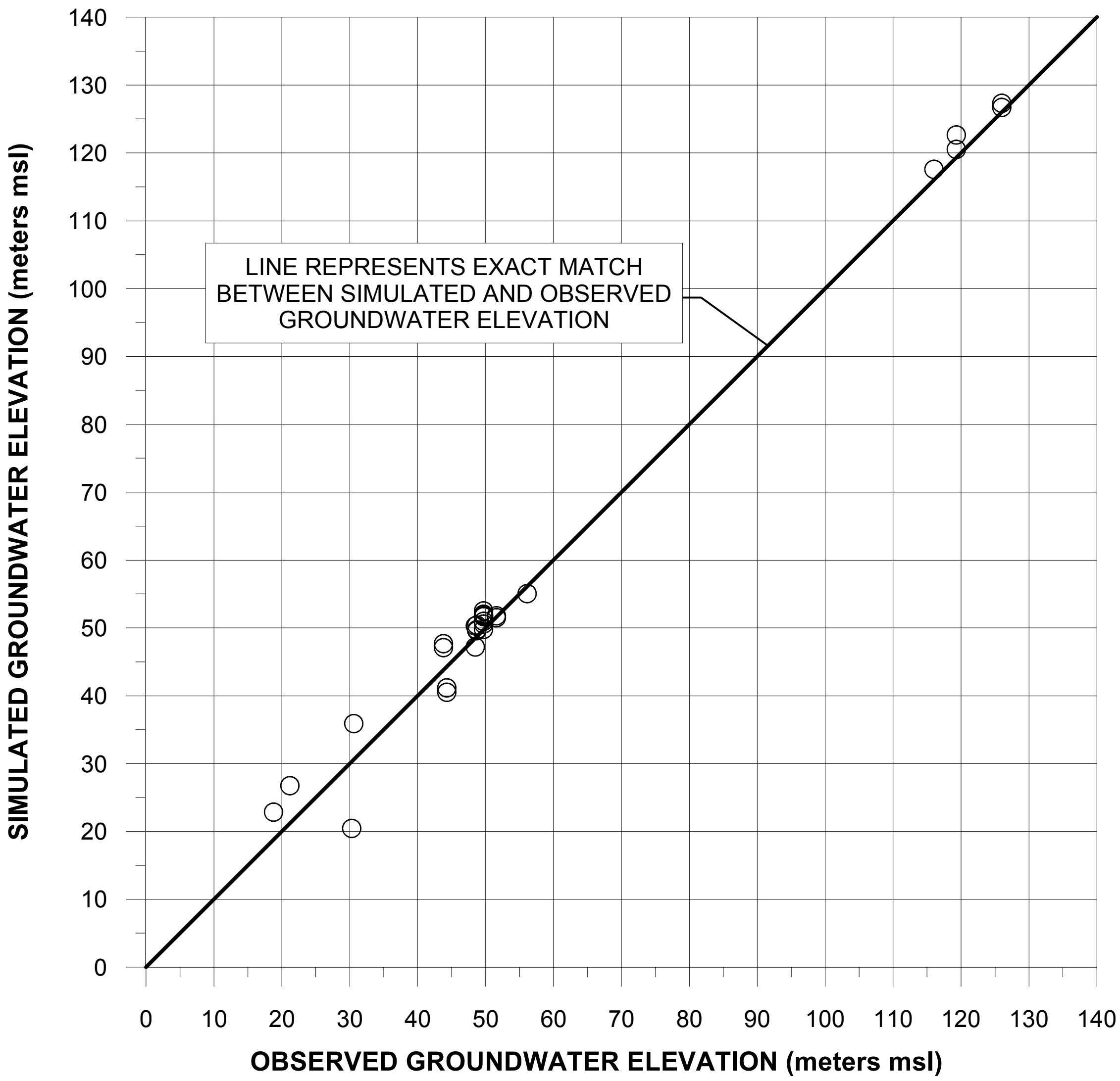

FIGURE 5-4
COMPARISON OF OBSERVED VERSUS SIMULATED GROUNDWATER LEVELS IN THE PERCHED AQUIFER
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

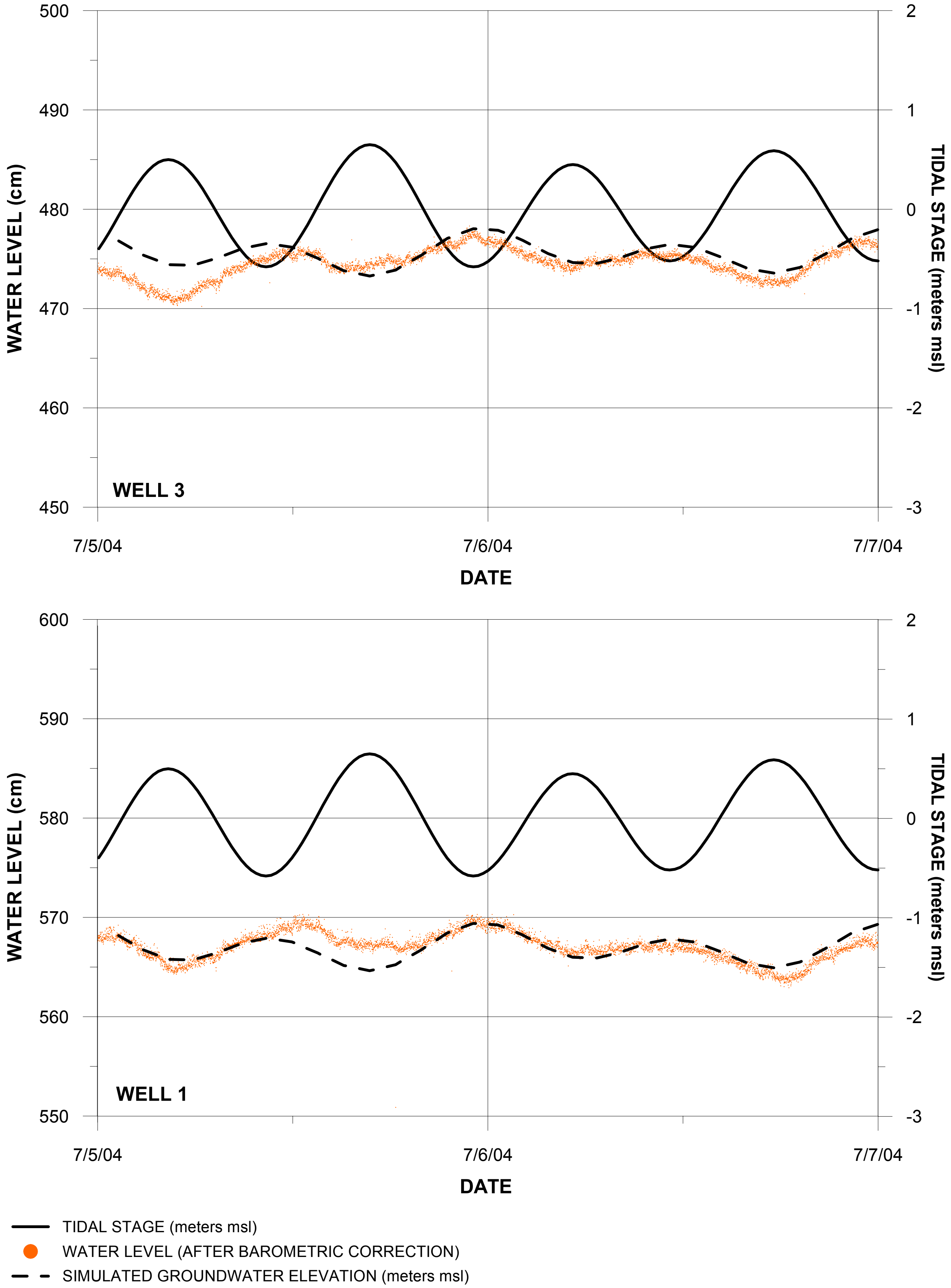

FIGURE 5-5
COMPARISON OF OBSERVED VERSUS SIMULATED GROUNDWATER LEVELS DUE TO TIDAL FLUCTUATIONS , WELL 1 AND 3
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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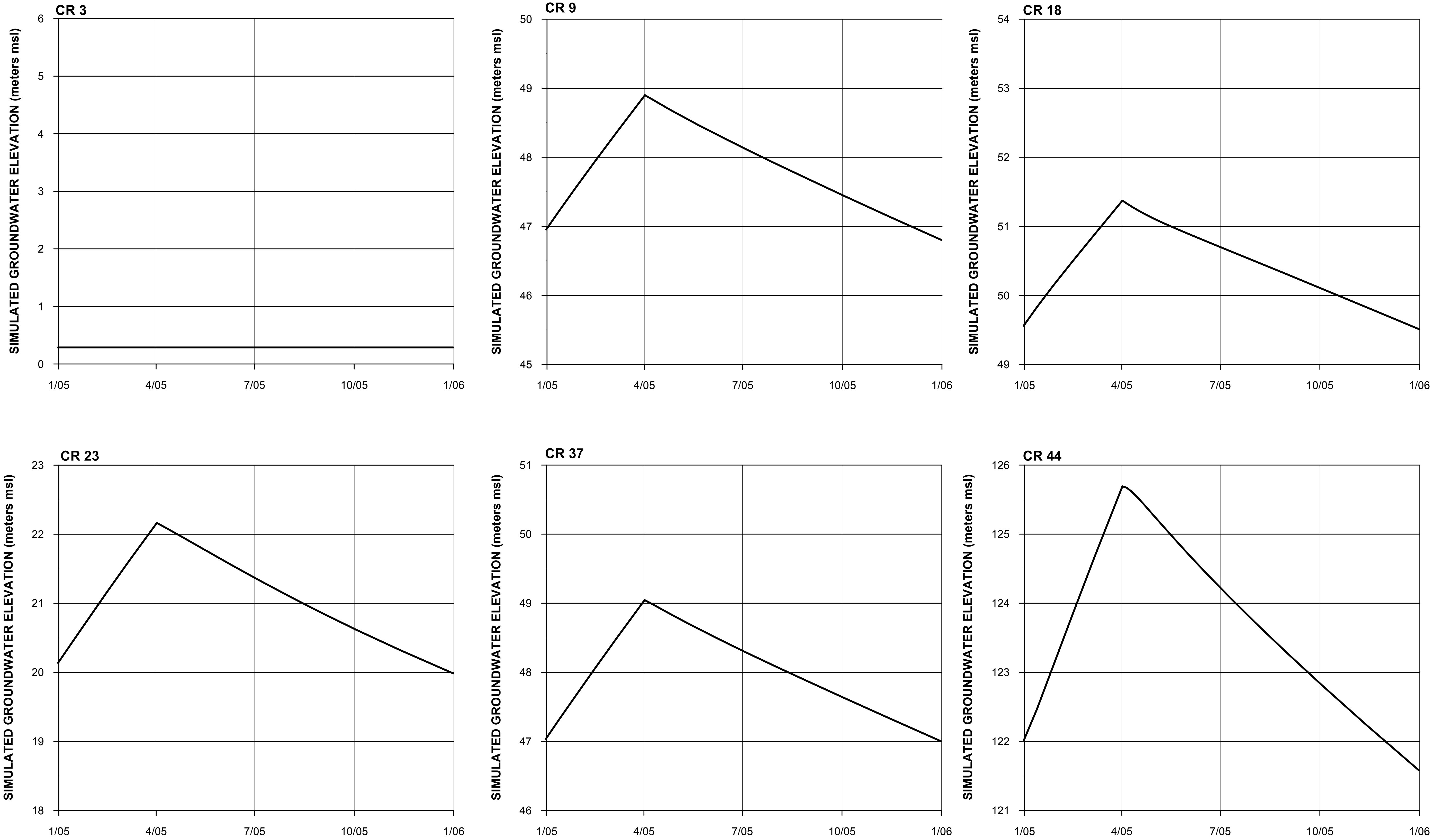

NOTE: LOCATION OF WELLS SHOWN ON FIGURE XX.

FIGURE 5-6
SIMULATED SEASONAL FLUCTUATION OF GROUNDWATER LEVELS IN THE PERCHED AQUIFER WELLS
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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FIGURE 5-7
SIMULATED AND OBSERVED GROUNDWATER ELEVATIONS AND GROUNDWATER FLOW DIRECTION IN THE BASAL AQUIFER

HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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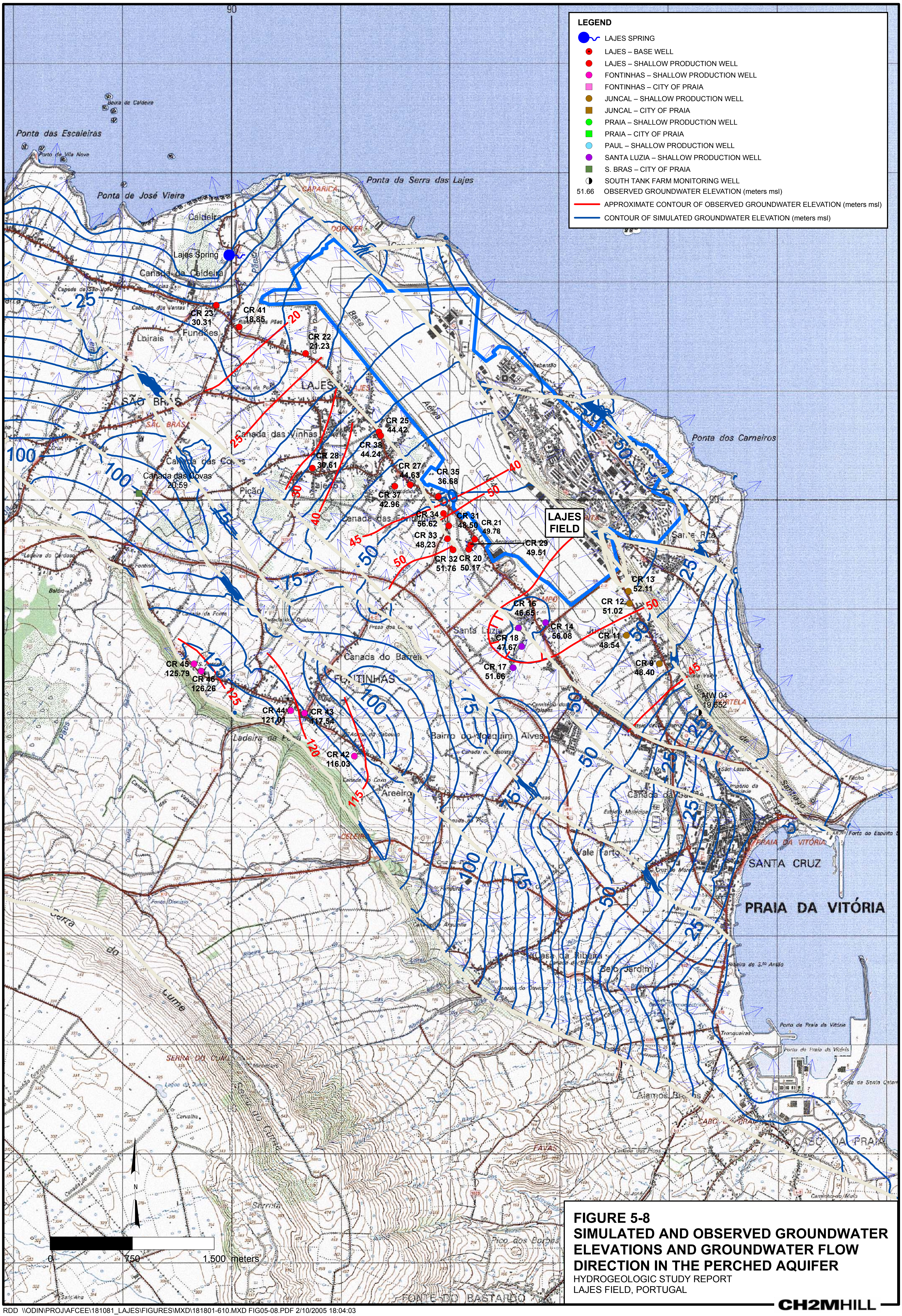

FIGURE 5-8
SIMULATED AND OBSERVED GROUNDWATER ELEVATIONS AND GROUNDWATER FLOW DIRECTION IN THE PERCHED AQUIFER
HYDROGEOLOGIC STUDY REPORT
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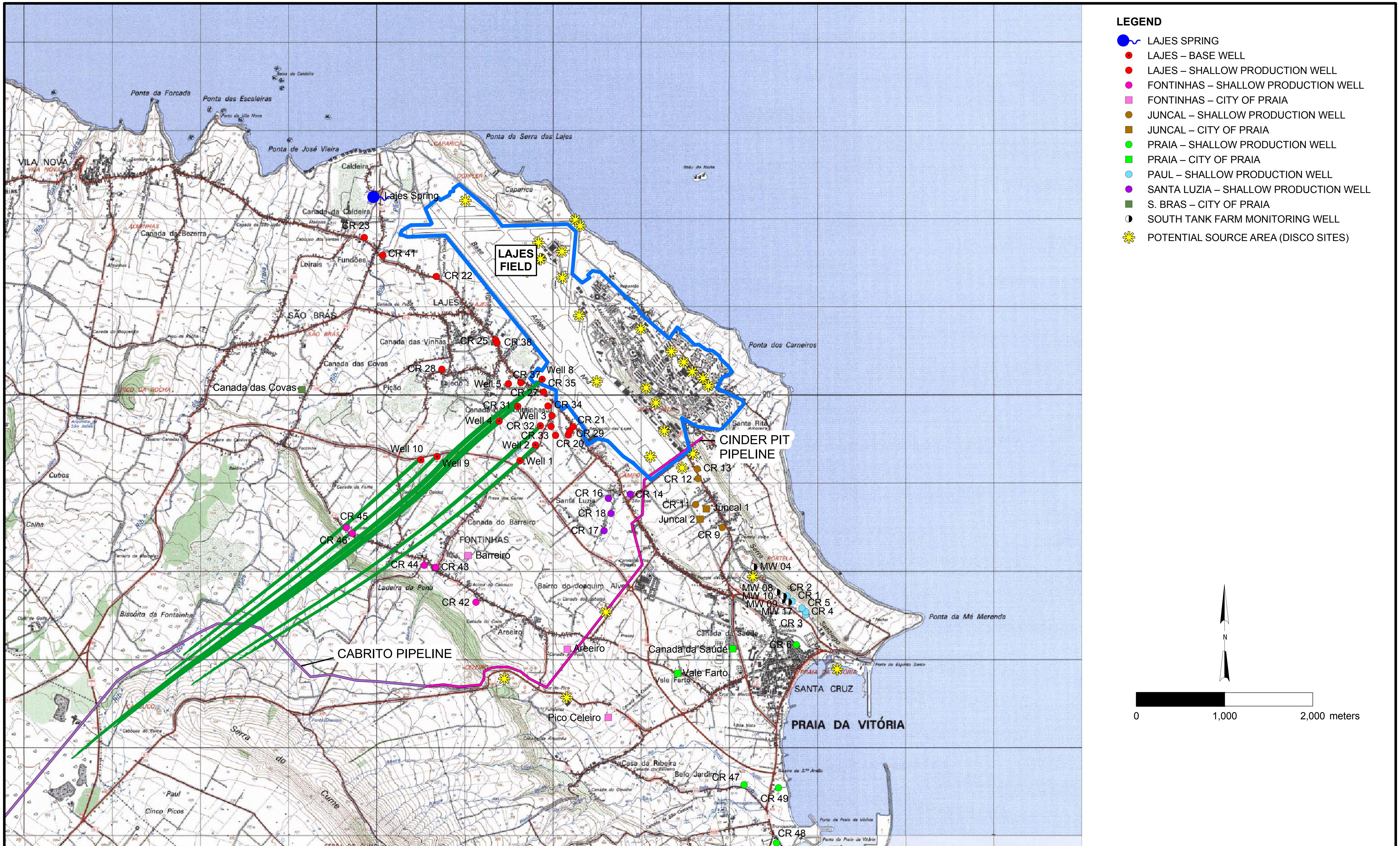

FIGURE 5-9
SOURCE OF GROUNDWATER PUMPED FROM THE BASE WELLS
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CH2MHILL

SECTION 6.0

Assessment of Known and Suspected Contaminated Sites at Lajes Field – Groundwater Situation

In the Discovery Study (CH2M HILL, 2004) four of the 38 identified suspected contaminated sites were considered as being known contaminated sites, either since subsurface contamination was confirmed in previous investigations or contamination is practically certain due to activities onsite. The locations of these sites are shown in Figure 6-1. These four sites will be discussed in the following sections in more detail with respect of the currently known groundwater situation. The suspected contaminated sites are discussed in Section 6.5.

6.1 South Tank Farm (Site 5001)

The South Tank Farm was identified as a known contaminated site in the DISCO report (CH2M HILL, 2004).

It consists of 12 large ASTs (in concrete secondary containment) with a total of 64 million gallons fuel storage capacity and is thus among one of the largest bulk fuel storage facility in the US Air Force.

The South Tank Farm site is located midway between Lajes Field main base area and the Praia docks, where tankers unload the fuel. The layout of the tank farm was completely changed between 1982 and 1986. The former tank farm once comprised 18 fuel ASTs, which were standing on unlined ground and surrounded by earthen containment dikes. Reportedly, it was common practice to use fuel to wet the soils under large field-assembled tanks in order to compact these soils to provide a level ground for building the tanks. Historic activities at the South Tank Farm included burying sludge next to the access ports of the tanks that was generated during tank cleaning. Since these tanks held AVGAS before 1982, the sludge contained high levels of tetraethyl-lead (TEL), as well as TPH and BTEX. Numerous spills are known for the site. According to Liquid Fuels personnel, not all contaminated soils could be removed and an unknown amount was spread during the massive earth-movement activities that were required for the reconstruction. Sixteen of the 18 tanks were demolished during this reconstruction; only tanks T-1605 and T-1606 were retained. Ten new tanks were constructed, which all still exist today.

The Army Corps of Engineers performed a site investigation in 1996, encountering soil and groundwater contamination with diesel-ranged TPH. Impacted areas were identified mostly in the southeast portion of the site around the soil borings SB08, SB09, SB10, and SB11 with free phase petroleum product in SB08. A total of 15 soil borings were drilled; 34 soil samples and 16 water samples were collected. Nine of the borings were converted to monitoring wells if water was encountered in a borehole. Five of these monitoring wells still existed in June/July 2004 and were sampled by CH2M HILL, corroborating the findings of 1996 (as discussed in Section 6.1.2).

6.1.1 Local Hydrogeologic Conditions and Flow Directions

The site is situated between two 'Y'-shaped geological faults. The foothills of the Serra de Santiago represents one of the main geologic faults of Terceira (Santiago Fault), located roughly parallel to the eastern site border, forming the eastern boundary of the Lajes graben. A secondary fault runs in northwestern direction along the slope parallel to the road between the southern entrance of the South Tank Farm and Santa Luzia/Lajes Village.

The topographic elevation of the South Tank farm ranges between approx. 3 m msl in the southeastern portion to and approx. 40 m msl to the northwest. Monitoring wells in the low portion (i.e. MW 17, MW 09 and MW 10) intercept the basal aquifer, whereas the monitoring wells at higher locations yielded only small amounts of perched waters during the 2004 sampling. Due to the massive earthworks and soil compaction during the reconstruction of the South Tank Farm, it is likely that the perched aquifer is discontinuous with only minor water-bearing units.

Groundwater occurring in the main drinking water aquifer at Terceira floats atop saline waters. Impact is possible by direct contaminant migration into this aquifer (possible in the southern portion of the site) or by seepage from impacted perched waters. Such migration could be facilitated due to the geological fault at the site. However, the public drinking water wells in the surrounding area are located upgradient (both Juncal wells to the NW and the Canada de Saude well to the SW). However, several private water supply wells, mainly old dug wells that are mostly used for irrigation, are located in the vicinity of the site.

Spills that cannot be retained within the storm drain OWS could potentially reach the Marina Harbor at Praia da Vitoria. Major tank raptures (e.g. during earthquakes) could potentially affect the community of Praia da Vitoria and its harbor area.

The perched aquifer that underlies the site is discontinuous and has been extensively altered by the intensive earthworks that occurred during the redevelopment of the South Tank Farm. Thus, gradual downward infiltration can be assumed rather than lateral movement, except in the rainy winter season, when, occasional flooding is reported for the lower portions of the site.

Based on the hydrogeologic model, the basal aquifer would have a southeastern flow direction, passing under the Serra de Santiago. Groundwater flow directions simulated with the model are presented on Figure 6-3. This would corroborate the fact that there is no natural spring at the Praia Harbor area. However, flow directions for this site should be interpreted carefully, due to information gaps, since no wells are located east of the ridge of Serra de Santiago.

6.1.2 Sampling Results

The five still existing monitoring wells were purged on 1 July and groundwater samples were collected 2 July 2004 (CH2M HILL, 2004 – Data Summary Report, Groundwater Sampling at Lajes Field). Additionally, field parameters, as well as drawdown/recovery data during well pumping were measured if applicable. The remaining 4 monitoring wells could not be located using a metal detector, trying to find the solid metal lid the Army Corps of Engineers used 1996 for the flush-mount design of these monitoring wells. The wells not found were mostly located in areas that were developed and graded, thus it can be assumed that these wells were destroyed.

Field observations during sampling:

MW 17: waters were very cloudy, purging removed silty and muddy waters from the bottom of the well; light odor of weathered fuel; well yields very good quantity and recovers rapidly.

MW 09: free product that was floating in the well was removed during purging and 5,1 cm of yellowish free product was discovered before sampling the next day, significant fuel odor; well yields very good quantity and recovers rapidly.

MW 10: clear water with faint weathered fuel odor; observed original chippings from sawing the PVC casing; well yields very good quantity and recovers rapidly.

MW 08: free product that was floating in the well was removed during purging and 26 cm of brownish-yellowish free product was discovered before sampling the next day, significant fuel odor; sampled with bailer due to very low recharge of the well.

MW 04: some weathered fuel odor; sampled with bailer due to extremely low recharge of the well – the amount of waters that could be retrieved from the well (3l) was not sufficient to perform all analytical analysis.

Analytical results:

- The water sample from MW 08 shows a similar concentration of diesel range organics (DRO) as that found in the floating free product sample from the same well. Conversely, the water sample from MW 09 is significantly lower in concentration of DRO than that of the associated floating free product sample of the same well. Collection and analysis of a water sample in the presence of a product layer can be difficult, with cross contamination of phases likely. A very small amount of the free product remaining on the water sample can effectively increase the final detected concentrations.
- An evaluation of the free phase product from MW 08 and MW 09 and the water phase from several wells tested for fuels has the following observations:

Heavier, extractable fuels:

- Free product from both locations have a pattern in the chromatography indicative of a petroleum hydrocarbon which may be a diesel fuel, beginning around carbon 12 and ending around carbon 28. This carbon range is typical for a diesel fuel.
- The analysis of MW 08 groundwater shows a very similar petroleum hydrocarbon fingerprint to the associated free product in MW 08.
- The analysis of MW 09 groundwater shows a very low response with a rising baseline in a similar carbon range of the associated free product from MW 09.
- The analysis of MW 10 groundwater shows a petroleum hydrocarbon pattern in the diesel fuel range with the typical rising baseline but lacking many of the sharp hydrocarbon peaks characteristic of the free product.

Lighter volatile fuels:

- MW 08, MW 09 and MW 17 contain significant amounts of extractable fuels. The chromatography suggests that these consist mostly of a fuel heavier than gasoline, possibly one of the lighter jet fuels.

The analytical results for the five wells are shown in the following Table 6-1:

TABLE 6-1

Summary of Analytical Results

Units	Analyte	MW 04	MW 08	MW 08 free phase oil	MW 09	MW 09 free phase oil	MW 10	MW 17
mg/Kg	HC > C12 < C28			1180000		1200000		
µg/L	alkalinity as CaCO3	44900	374000		306000		161000	494000
µg/L	Aluminum	3890 B	993 B		304 B		233 B	1100 B
µg/L	Antimony		0.435					0.251
µg/L	Arsenic	1.36	1.98		2.56		1.4	3.77
µg/L	Barium	22.4	31.5		132		26	175
µg/L	beryllium	0.694						
µg/L	cadmium	0.655 B						
µg/L	chromium	4.67					1.35	
µg/L	cobalt	0.76	1.16		7.96		0.399	6.03
µg/L	copper	4.09 B						
µg/L	iron	3600 B	3450 B		30900		2760 B	26200
µg/L	lead	5.09	34.1		10.3			15.9
µg/L	manganese	67.3	340		2190		3870	4420
µg/L	mercury	1.08						
µg/L	nickel	4.32 B	1.29 B					1.78 B
µg/L	selenium	3.3	1.68		1.63		4.52	5.09
µg/L	silver	0.144 F						
µg/L	thallium						0.107	
µg/L	vanadium	8.38	0.916 F		0.703 F		0.679 F	1.62
µg/L	zinc	26.4 B	29.2 B		12.7 B			23.1 B
µg/L	HC > C12 < C28	47.3 J	971000 J		1060 J		746 J	870 J
µg/L	HC < C12		2310 J		1610 J			1110 J
µg/L	1,1-dichloroethane						0.06 F	
µg/L	1,2,4-trimethylbenzene		0.09 F					0.12
µg/L	benzene		0.23					
µg/L	bromodichloromethane							
µg/L	bromoform							
µg/L	chloroform							
µg/L	dibromochloromethane							
µg/L	ethylbenzene		52.5 B		25.4 B			14.2 B
µg/L	isopropylbenzene		308 B					85.6 B
µg/L	m,p-xylene							0.58
µg/L	naphthalene		43.5 B		19.2 B			13.7 B
µg/L	n-butylbenzene		3.5 B		1.87 B			2.79 B
µg/L	n-propylbenzene		16.9 B		8.29 B			31.6 B
µg/L	o-xylene		1.1		0.11			0.3

TABLE 6-1

Summary of Analytical Results

Units	Analyte	MW 04	MW 08	MW 08 free phase oil	MW 09	MW 09 free phase oil	MW 10	MW 17
µg/L	p-isopropyltoluene		0.22					0.41
µg/L	sec-butylbenzene		6.85 B		4.22 B			5.16 B
µg/L	t-butylbenzene		3.29 B		0.57 B		0.88 B	1.74 B
µg/L	tetrachloroethene							
µg/L	2-methylnaphthalene		1260 J		15.2 J			2.7 J
µg/L	acenaphthene	0.13 J	42.3 J		0.936 J		0.0884 J	0.166 J
µg/L	acenaphtylene	0.0612 J	45.6 J		0.339 J		0.0244 J	0.0241 J
µg/L	anthracene	0.129 J	124 J		0.694 J		0.212 J	0.03 J
µg/L	benzo[a]anthracene				0.0139 J			
µg/L	benzoic acid	1.05 J					1.71 J	
µg/L	bis(2-ethylexyl)phthalate	1.7 J	88.4 J					
µg/L	chrysene		1.8 J		0.0373 J			
µg/L	dibenzofurane	0.325 J	187 J		1.32 J			
µg/L	diethylphthalate							0.467 J
µg/L	dimethylphthalate				0.531 J			
µg/L	di-n-octylphthalate	0.0907 J	26.7 J		0.41 J			
µg/L	fluoranthene		9.37 J		0.0711 J			
µg/L	fluorene	0.538 J	207 J		2.53 J			
µg/L	naphthalene		35 J		9.98 J		0.68 J	9.18 J
µg/L	phenanthrene	0.393 J	274 J		1.99 J		0.538 J	
µg/L	phenol							
µg/L	pyrene		6.05 J		0.0843 J			
µg/L	chlorides	68300 B	40800 B		64600 B		81000 B	66100 B
µg/L	nitrogen as (NO3)	2360			2.5 F			
µg/L	sulfate	21600					12600	

6.1.3 Recommendations for Future Work

In order to assess the risk to groundwater, the installation of additional monitoring wells should be considered for the southern portion, especially towards the southwestern site boundary. These should be drilled in both the basal and perched aquifers in order to assess the groundwater quality and contaminant stratification. Recommended locations for monitoring wells are shown on Figure 6-3.

6.2 Main Gate/5 Hydrant Area (Site 3001)

With approximately 35 acres, the Main Gate/5 Hydrants Area is the largest area of concern identified at Lajes Field.

An abandoned hydrant refueling system, a fuel dispenser rack, an abandoned pipeline that is known to have leaked and numerous other pipelines are situated in this area. Additionally, especially the eastern portion was utilized for bulk fuel storage since the 1950's.

A subsurface investigation conducted by IT Corporation in 1995 confirmed BTEX contamination in 88 of the 100 samples collected from the site, discovering several hot spots:

- Between T-701 and T-705 where the abandoned JP-4 and the diesel line cross: maximum concentrations >1,000 ppm; elevated BTEX contamination along the abandoned diesel line; often free product was encountered.
- Along the abandoned JP-4 pipeline between T-706 and the Apron A: BTEX contamination was observed with a maximum concentration of 480 ppm.
- Along the southern Base fenceline: elevated BTEX concentrations were encountered. These contaminations are believed to have originated from leaks in the JP-4 or the diesel pipeline between the manifolds at T-711 and the dispenser rack.

Offbase soil/groundwater contamination is possible, but was never investigated.

An abandoned drinking water well (former Base Well 6) used to be located in Building T-713, which was demolished in early summer 2004. Presuming that this well could be potentially transformed to a monitoring well, CH2M HILL recommended 2003 to protect this well during the demolition of T-713, which however was not done. This well may have provided a preferential pathway for contaminants to the basal island aquifer.

The Main Gate Area/5 Hydrants Area is considered the most problematic site on Lajes Field due to the extent of fuel contamination and the possibility of offsite migration, including the potential impact of public supply wells.

6.2.1 Local Hydrogeologic Conditions and Flow Directions

If a perched aquifer exists within the site premises, it can be assumed to be discontinuous. Seasonally perched waters are presumed to build-up during rainy winter season, due to waters seeping from the steep slope of the Serra de Santiago ridge. Flow directions were calculated in the hydrological model to be in eastern and southeastern directions. However, since the terrain is almost level, gradual downward infiltration can be assumed rather than lateral movement.

Based on the hydrogeologic model, the basal aquifer was computed to have an eastern flow direction, passing under the Serra de Santiago. Groundwater flow directions simulated with the model are presented on Figure 6-4. However, flow directions for this site should be interpreted carefully, due to information gaps, since no wells are located in this area and east of the ridge of Serra de Santiago.

Both public supply wells of the village of Juncal (Juncal 1 and Juncal 2 wells) are located approximately 2,100 feet SSE of the main gate and could be impacted if a fuel plume exists that could reach the drawdown cone of these wells.

6.2.2 Recommendations for Future Work

CH2M HILL recommends locating the former Base supply well under demolished T-713 and investigating whether it can still be transferred to a monitoring well or whether it should be properly grouted and closed. CH2M HILL measured the approximate location with a hand-held GPS during the July 2004 field visit to facilitate finding this well in case the vegetation grows. The measured UTM coordinates for the well location at former T-713 were: 26 4289216N/0493359E.

The installation of several additional monitoring wells is deemed warranted for this site, especially in the check house area and along the southern fenceline. If perched waters are encountered, the installation of some shallow wells should be considered in addition to deeper wells, intercepting into the basal aquifer. These monitoring wells are essential for assessing groundwater quality at the Main Gate/5 Hydrants Area. An area showing the potential locations from these wells is shown on Figure 6-4.

6.3 Cinder Pit Fuel Tanks (Site 5002)

The Cinder Pits Fuel Tank Site consists of five ASTs and six USTs on a foothill of the Serra do Cume-ridge, northeast of the village of Fontinhas. This tank farm has a total capacity of 759,000 bbl and was in used from construction in the 1950s until decommissioning in 1994. Most of the associated buildings are already demolished and the tanks are awaiting demolition or transfer. All tanks, except the tanks at the *Estrada Joaquim Alves* (T-1330 and T-1331 -Cinder Pit 1) are located right on the ridge that was formed by the Fontinhas Fault. An 18,500-foot long double 12-inch fuel pipeline connects the Cinder Pit tanks to the Lajes Field main Base area (a.k.a. Cinder Pit Pipeline, Site 5011). A second pipeline, the so-called Cabrito Pipeline (Site 5012) is an 8-inch fuel pipeline that runs 28,818 feet (5.4 miles), connecting the Cabrito Tank Farm to the Cinder Pit Tank Farm.

Two burial sites for tank sludge are known at the tanks T-1341 and T-1342, additional are likely.

The Army Corps of Engineers drilled 12 soil borings during the 1996 investigation of the Cinder Pit Tank Farm. Three borings were installed at ‘Cinder Pit 1’, four borings at ‘Cinder Pit 2’ and five borings at ‘Cinder Pit 3’. The depth of the borings ranged between 5 feet to 35 feet below ground surface. No groundwater was encountered in any of the borings. Soil samples were collected from the borings and analyzed for TPH and VOCs. Two of these samples exceeded the TPH-diesel initial screening action levels (ISALs) of 500 mg/kg. The results were 1,540 mg/kg in SB04 (situated between tanks T-1313 and T-1314) and 730 mg/kg in SB09 (drilled downgradient of the fuel pump house T-1310).

6.3.1 Local Hydrogeologic Conditions and Flow Directions

The existence of a perched aquifer in this area is unknown because no wells appear to exist in the area. If it exists, it is deeper than the soil borings drilled by the Army Corps of Engineers in 1996. None of these soil borings encountered water at depths above msl. The quarried cinder and the slope deposits are presumed to be very porous, facilitating infiltration.

The flow direction in the perched and basal aquifer computed in the hydrogeologic model follows the natural grade in northeastern direction. Groundwater flow directions simulated with the model are presented on Figure 6-5. Several public supply wells for the City of Praia da Vitoria are located downgradient of the site with the two closest wells situated approx. 460 m (1,500 feet) N and NE of the tanks. The 1995 MAP report (Radian 1995) states that residents in the vicinity of the tank T-1330 have complained about water having a fuel odor and taste

6.3.2 Recommendations for Future Work

CH2M HILL recommends installing monitoring wells downstream of the sites, especially towards the public supply wells. These wells could act as sentinel wells for the supply wells if groundwater should be impacted. The groundwater quality should be assessed and periodically monitored. Locations for monitoring wells in both the perched and basal aquifers are presented on Figure 6-5.

6.4 Fire Training Pit (Site 3002)

The former fire training area/pit is situated in the northern corner of the Lajes Field main Base area, approximately 250 yards east of the end of the runway and 160 yards southwest of the north drainage ditch. The pit consists of two concentric circles; the inner circle has a diameter of approximately 100 feet with a surface of overgrown, unimproved soil and some gravel, the outer circle has a diameter of approx. 400 feet and consists of a mixture of asphalt, soils and gravel with little vegetation.

Although the site was never investigated, based on available information, it can be strongly assumed that subsurface contamination was caused by historic operations on unimproved ground. Routine fire fighting training was performed at this area until 1982. The common practice was to douse fuel over a mock plane in the center of the inner circle and set the plane on fire. The compounds used include various fuel types, halon, foam and presumably also flammable liquid wastes.

6.4.1 Local Hydrogeologic Conditions and Flow Directions

The subsurface materials in the area of the Fire Training Pit are presumed to be very permeable, supported by the observation that waters from the nearby North Drainage Ditch rather tend to infiltrate than running to the ocean. The hydrological model calculated flow directions of the perched aquifer to follow the slight surface inclination in northern and northwestern directions. However, since the gradient is low and subsurface permeable, gradual downward infiltration is more likely than lateral movement.

The flow direction of groundwater in the basal aquifer was computed to be towards north, passing under the Serra de Santiago or being redirected to northwestern direction by the Santiago Fault. Groundwater flow directions simulated with the model are presented on Figure 6-6. However, flow directions for this site are uncertain, due to information gaps, since only few wells are located in the area. The closest of these wells is a public supply well, located at Caldeira, approximately 850 m (2,800 feet) west of the site. Although the computed flow direction indicates no immediate risk for this well, future impact could be possible if a subsurface plume exists, which then could be intercepted by the drawdown cone of this well.

6.4.2 Recommendations for Future Work

CH2M HILL recommends investigating soil and groundwater condition at the site and its surroundings, preferably in a stepwise approach. If soil condition indicates the possibility of a groundwater impact, the installation of monitoring wells is deemed warranted. The groundwater quality should be assessed and periodically monitored.

6.5 Suspected Contaminated Sites

Of the 38 total sites, the DISCO study (CH2M HILL, 2004) identified 4 known contaminated and 34 suspected sites. These suspected contaminated sites require an investigation in order to assess if they bear an associated risk for the environment, human health or the mission.

In the DISCO report, CH2M HILL laid out the technical opinion that 14 of these 34 suspected contaminated sites are considered most likely contaminated and/or pose a relatively high threat to the environment or to human health, as compared to other sites. CH2M HILL tried prioritizing these 14 sites according to their likelihood of being contaminated or the potential threat they represent. This provisionary priority list shall be revised during the data gathering process of the subsequent risk assessments:

- Site 5011 – Cinder Pit Pipeline
- Site 5012 – Cabrito Pipeline
- Site 2009 – Transformer Yard
- Site 3012 – Asbestos Dump Site
- Site 2005 – BX Gas Station
- Site 3003 – Main Power Plant
- Site 5003 – North Storm Sewer Drainage Outfall
- Site 5013 – Military Highway Spill
- Site 2008 – Old Pesticide Shop
- Site 2007 – DRMO/Manny's Garage
- Site 5009 – Cume da Tacan Annex Number EYNH
- Site 5008 – Cinco Picos Globe Com Annex Number XYNJ
- Site 3007 – 18 Hydrants Area
- Site 3005 – 7 Hydrants Area

This listing does not imply that the remaining twenty sites are considered free of contamination; these twenty sites were often significant historic sources of contamination, possibly also impacting local soil and groundwater at the sites and their surrounding.

To assist in evaluating the possible impact of these sites, the simulated groundwater flow directions at each of these sites were computed using the groundwater model. These are shown on Figure 6-7. These flow directions should be considered approximate only.

6.5.1 Abandoned Offbase Pipelines, Site 5011 Cinder Pit Pipeline and Site 5012 – Cabrito Pipeline

These two abandoned pipelines were considered to have a high priority due to the circumstances that they were not completely drained when decommissioned between 1994 and 1997, posing the risk to release fuel on private properties and/or the subsurface and groundwater if punctured or corroded. The Cabrito Pipeline is an 8-inch pipeline

that runs 28,818 feet (5.4 miles), connecting the Cabrito Tank Farm to the Cinder Pit Tank Farm. The Cinder Pit Pipeline is an approximately 18,500 feet (3.5 mile) long two 12-inch pipeline connecting the Cinder Pit Tank Farm to Lajes Field main Base at the manifold near T-711. Both pipelines run through uneven terrain with several low points that are suspect to still contain fuel remains.

6.5.1.1 Local Hydrogeologic Conditions and Flow Directions

Both pipelines use the natural inclination towards Lajes Field, roughly following the former slopes of the Cinco Picos volcano. Thus, various geologic formations are intercepted, mainly the Cinco Picos Trachybasalt Formation and Slope Deposits. The passageway of the pipelines is mainly used for agriculture with scattered residences and a few industrial developments. Some of these developments are very close to the pipelines (e.g. residences in São Jose).

The hydrogeologic model covers only the eastern portions of the pipeline runs, however, it can be assumed that groundwater flow direction tends to be parallel to the natural topographic inclination. Consequently, northeastern flow directions are assumed to prevail for the western portion, turning to more eastern directions towards the eastern sections of the pipeline runs. Numerous private wells that are mainly used for irrigation and dairy cattle are located in the area. Additionally, the pipeline comes as close as 100 m to public supply wells and is crossing the simulated source area for the Base well field (see Figure 5-9 and 6-7).

6.5.1.2 Recommendations for Future Work

CH2M HILL recommends confirming the exact location of the pipelines and subsequently determining their condition and performing a leak test along the passageways. An investigation of soil, soil vapor and groundwater condition may become warranted if leaks are suspected or confirmed. Additionally, it would be prudent to determine the amount and location of fuel in the pipeline (e.g., with a CCTV-camera or similar methods).

6.5.2 Sites in Area 3000 (and adjacent Sites 5004 and 5005)

The following four of the 14 suspected sites that are considered most likely contaminated are located within the functional area 3000 (refer to the DISCO Study, CH2M HILL, 2004):

- Site 3003 – Main Power Plant
- Site 3005 – 7 Hydrants Area
- Site 3007 – 18 Hydrants Area
- Site 3012 – Asbestos Dump Site

Hydrogeologically, the Area 3000 can be subdivided in these groups sharing similar hydrologic conditions.

1. The Main Gate section and southern portion of the Avenida do Imperio (Sites 3001, 3003, 3004 and 5014)
   - Due to its proximity, the Main Power Plant (Site 3003), the Former Military Gas Station (Site 3004) and the Former Running Track (Site 5014) should rather be investigated in conjunction with the Main Gate/5 Hydrants Area (Site 3001, see Section 6.2 of this report). These sites are all located near the Base main entrance

area SW of the Serra de Santiago ridge and are subjected to similar hydrologic conditions.

2. The Shops in the area of the runway triangle (Sites 3005 though 3013) and the cliff line (also including Sites 5004 and 5005)

   – The suspected sites in the area of the runway triangle are mostly facilities that have a small industrial-like scale related to aircraft/vehicle maintenance and refueling or similar activities (Sites 3005-7 Hydrants Area, 3006-Refueling Maintenance, 3007-18 Hydrants Area, 3008-LOX Plant, 3009-Refueling Truck Fill Stand, 3010-Torpedo Maintenance Shop, 3011-HazMart, Former Navy AC Maintenance and Site 3013-Joint Use Hangar).

   The northeastern end of the runway triangle was rather used for disposal due to its remote location (Site 3012 Asbestos Dump Site and the adjacent Sites 5004 - Praia Dump and 5005-EOD Area).

   The subsurface materials in the area of the runway triangle are presumed to be very permeable. Due to this permeability and the earthworks that were associated with the construction activities in the area, only a discontinuous perched aquifer can be assumed. The hydrological model calculated flow directions of the perched aquifer in northern directions, whereas the tip of the triangle would discharge directly towards the northeast to the ocean. However, since the gradient is low and subsurface permeable, gradual downward infiltration can be assumed rather than lateral movement.

   The flow direction of the basal aquifer was computed to be towards northeast, passing under the Serra de Santiago that is not that very prominent in this section. However, flow directions for this site should be interpreted carefully, due to information gaps, since very few wells are located in the area.

6.5.3 Sites in Area 2000 and 1000

The sites in the 2000 area are/were mostly service shops of Lajes Field (Site 2001-Power Plant Number, 2002-Transportation Maintenance Shop, 2003-Transportation Paint Shop, 2004-Laundry/Dry Cleaning Shop, 2005-BX Service Station, 2006-Auto Hobby Shop, 2007-DRMO/Manny's Garage, 2008-Old Pesticide Shop, 2009- Transformer Yard, 2010-Former MILSTAR Power Plant). The Site 1001 - Youth Center should be included in this group, since the hydrogeologic situation appears similar to the before mentioned locations.

No Known Contaminated sites are located in the 2000/1000 areas. Of the 14 most likely contaminated sites, only the following three sites are located in this area:

- Site 2005 – BX Gas Station
- Site 2007 – DRMO/Manny's Garage
- Site 2008 – Old Pesticide Shop

The hydrogeologic situation of this section is largely influenced by the topographic situation. This portion of the Base is developed on the eastern shoulder of the Lajes graben, towering above this graben with an elevation of up to 60 m higher (200 feet) than the graben. This shoulder has a very steep ridge along the Santiago Fault on its southwestern side and slopes gently towards the Atlantic on its northeastern side. Perched waters can only be assumed in few drainless depressions, thus stormwater

would infiltrate to the basal aquifer if not draining superficially to the Atlantic in small ravines.

The computer model calculated a flow direction of the basal aquifer towards northeast. This flow direction may be altered by the Santiago Fault. However, flow directions for the 2000/1000 area should be interpreted carefully; no wells are located in the entire area east of the Santiago Fault.

6.5.4 Offbase sites

The North Storm Sewer Drainage Outfall (Site 5003) should rather be investigated in conjunction with the Fire Training Pit (Site 3002) due to its proximity (discussed in Section 6.4 of this report). These two sites are both located at the northern Base fenceline, presumably sharing comparable hydrogeological features. The Site 5003 belongs to the 14 sites that are assumed most likely contaminated.

The Site 5004 - Praia Dump and Site 5005 - EOD Area should be assessed together with the sites located in the area of the runway triangle as, discussed in Section 6.5.2 of this report).

The Site 5006 - Vila Nova Power Plant is located at the northwestern fringe of the hydrogeological model. Groundwater flow directions were calculated to be northbound, directly towards the Atlantic. If contamination exists at the site, infiltrating waters may have washed contaminants to the basal aquifer. Because the village of Vila Nova is located downgradient of the site, it would be possible that groundwater used for cattle and/or human consumption could have been impacted. In CH2M HILL’s technical opinion it would be prudent to investigate this site to determine if a risk to the environment exists.

The Site 5008 - Cinco Picos Globe Com Annex Number XYNJ is located outside the hydrogeological model. Groundwater flow directions are assumed to be in southeastern directions following a very gentle inclination in this relatively flat area. The fact that no streams are developed in the area between Serra do Cume and Serra da Ribeirinha indicates very permeable conditions. Thus, perched water tables are considered sparse, rather infiltrating to the basal aquifer. This site belongs to the 14 sites that are assumed most likely contaminated. CH2M HILL recommends investigating this site to determine if a risk to the environment exists.

The Site 5009 - Cume da Tacan Annex Number EYNH is located on top of the crest of the Serra do Cume ridge with very steep drops to the NW and SE. Thus, neither significant perched waters, nor vulnerable groundwater is assumed at this site. It is considered to be one of the 14 sites that are assumed most likely contaminated. Therefore, it would be prudent to perform a soil investigation to determine it fuel-impacted soils are still present at the site.

The Site 5010 - Medium Port Command Maintenance Shop represents the harbor/dock site, where tankers deliver fuel. Due to its location at the shore of the Atlantic, no usable groundwater is assumed at this location. However, CH2M HILL considers it prudent to investigate if soils were impacted at the site (e.g. along the pipeline).

The Site 5013- Military Highway Spill is located on private property midway between Lajes Field main Base and the South Tank Farm (Site 5001). It is considered to be one of the 14 sites that are assumed most likely contaminated although the Portuguese Base Aérea No. 4, who handles cases between the Base and the public, considers this case

closed. The two public wells Juncal 1 and 2 are located in the close proximity of the site with approximately 600 to 700 feet to the SE and to the ESE respectively. These could be impacted if fuel contamination migrates in the drawdown cone of these wells. However, since the site was never investigated it is unknown whether it poses a risk to these wells. The computed flow direction of perched waters would be towards the Juncal wells. The groundwater flow direction was calculated to be in northeastern direction, passing under the Serra de Santiago.

The Site 5014 - Former Running Track is located just outside the main gate and should be investigated in conjunction with the known contaminated Site 3001- Main Gate/5 Hydrants Area (as discussed in Sections 6.2 and 6.5.2.of this report).

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DISCO SITES:

SITE 1001 – YOUTH CENTER
SITE 2001 – POWER PLANT NO. 2
SITE 2002 – TRANSPORTATION MAINTENANCE SHOP
SITE 2003 – TRANSPORTATION PAINT SHOP
SITE 2004 – LAUNDRY/DRY CLEANING SHOP
SITE 2005 – BX SERVICE STATION
SITE 2006 – AUTO HOBBY SHOP
SITE 2007 – DRMO/MANNY'S GARAGE
SITE 2008 – OLD PESTICIDE SHOP
SITE 2009 – TRANSFORMER YARD
SITE 2010 – FORMER MILSTAR POWER PLANT
SITE 3001 – MAIN GATE/5 HYDRANT AREA
SITE 3002 – FIRE TRAINING PIT
SITE 3003 – MAIN POWER PLANT
SITE 3004 – FORMER MILITARY GAS STATION
SITE 3005 – 7 HYDRANTS AREA
SITE 3006 – REFUELING MAINTENANCE
SITE 3007 – 18 HYDRANTS AREA
SITE 3008 – LOX PLANT
SITE 3009 – REFUELING TRUCK FILL STAND
SITE 3010 – TORPEDO MAINTENANCE SHOP
SITE 3011 – FORMER NAVY AC MAINTENANCE
SITE 3012 – ASBESTOS DUMP SITE
SITE 3013 – JOINT USE HANGAR
SITE 5001 – SOUTH TANK FARM
SITE 5002 – CINDER PIT FUEL TANKS
SITE 5003 – NORTH STORM SEWER DRAINAGE OUTFALL
SITE 5004 – PRAIA DUMP
SITE 5005 – EOD AREA
SITE 5010 – MEDIUM PORT COMMAND MAINTENANCE SHOP
SITE 5013 – MILITARY HIGHWAY SPILL
SITE 5014 – FORMER RUNNING TRACK
SITE 5011 – CINDER PIT PIPELINE
SITE 5012 – CABRITO PIPELINE

N

0 750 1,500 meters

FIGURE 6-1
LOCATION OF DISCO SITES
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

CH2MHILL

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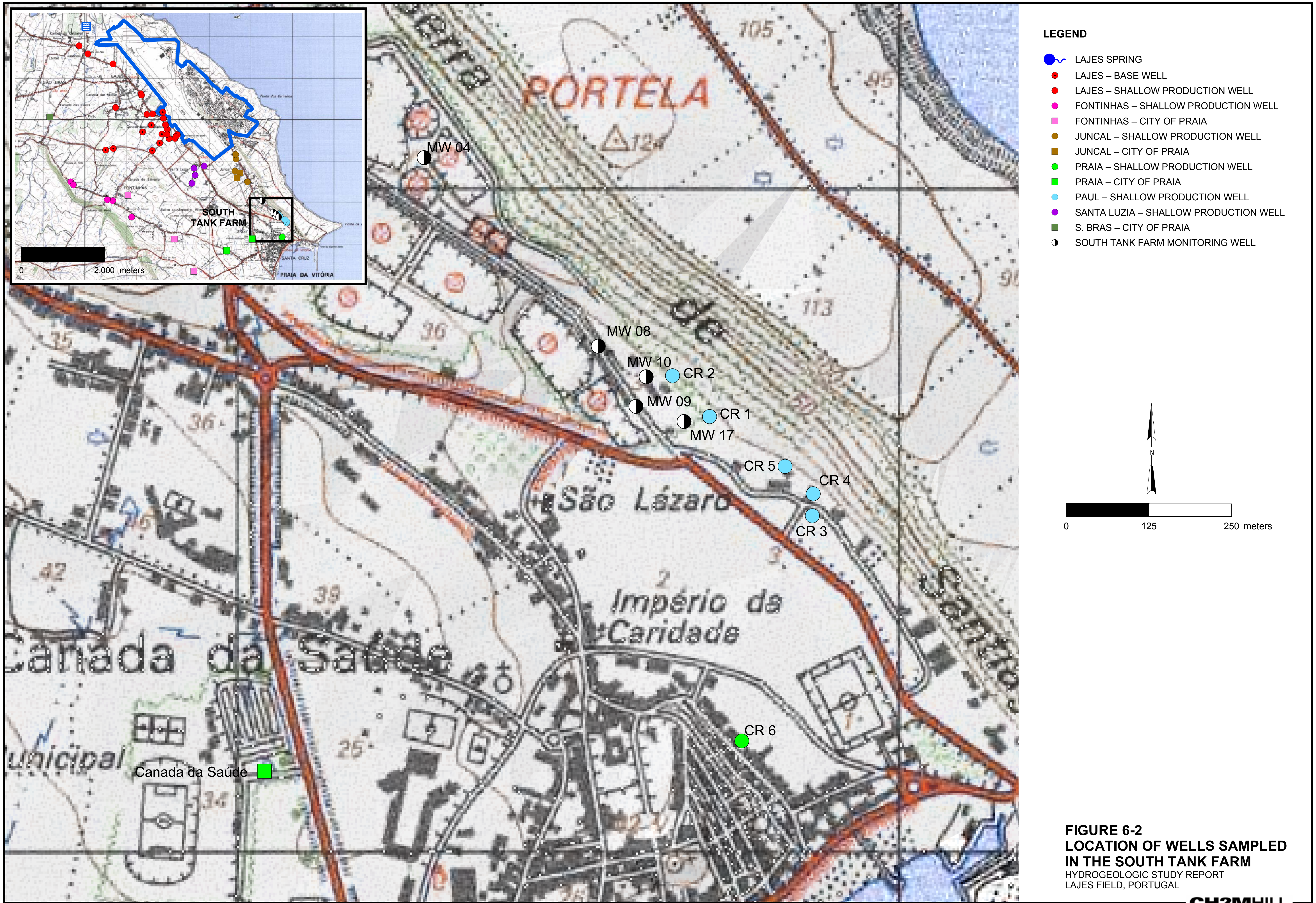

FIGURE 6-2
LOCATION OF WELLS SAMPLED IN THE SOUTH TANK FARM
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

CH2MHILL

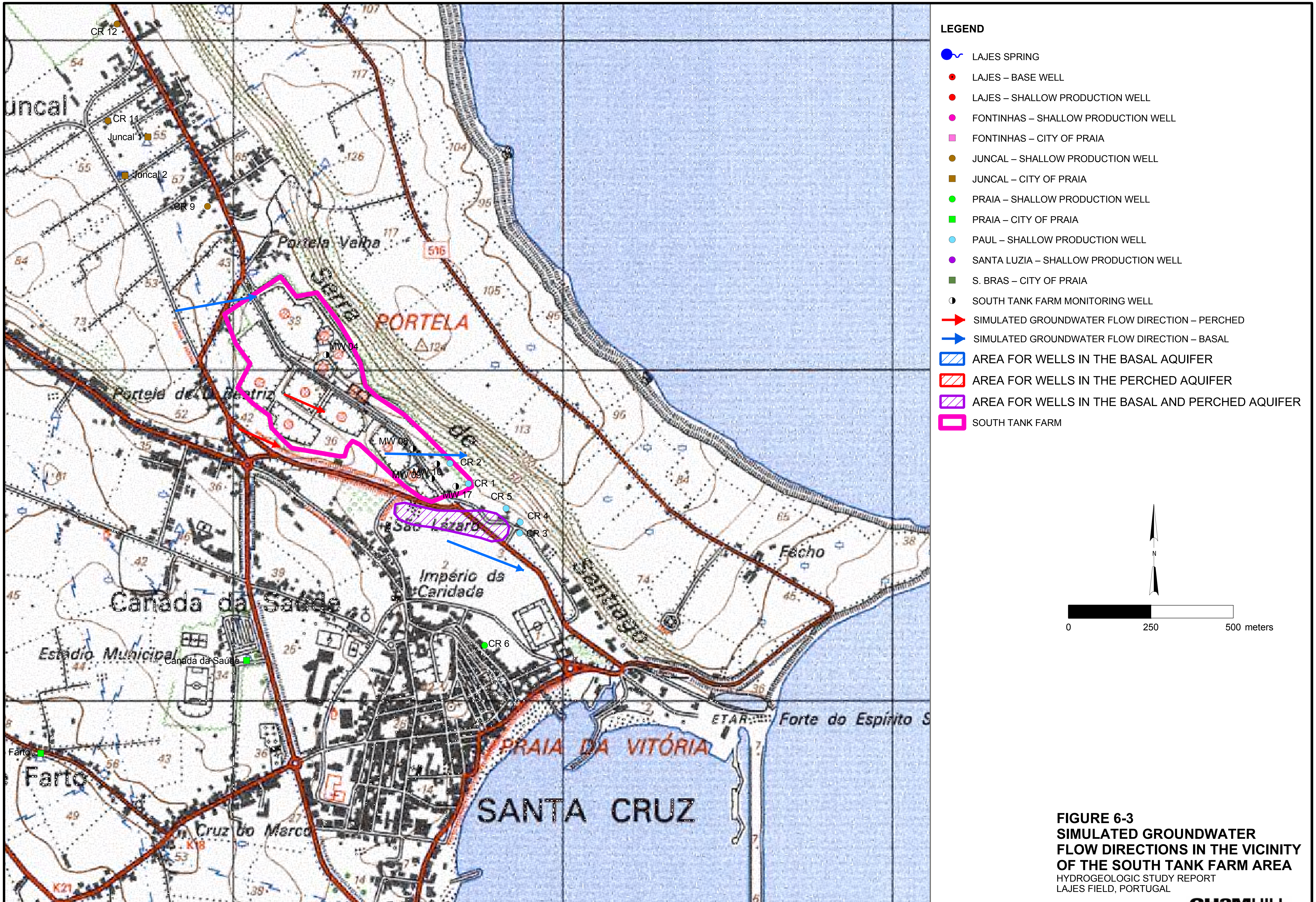

FIGURE 6-3
SIMULATED GROUNDWATER FLOW DIRECTIONS IN THE VICINITY OF THE SOUTH TANK FARM AREA
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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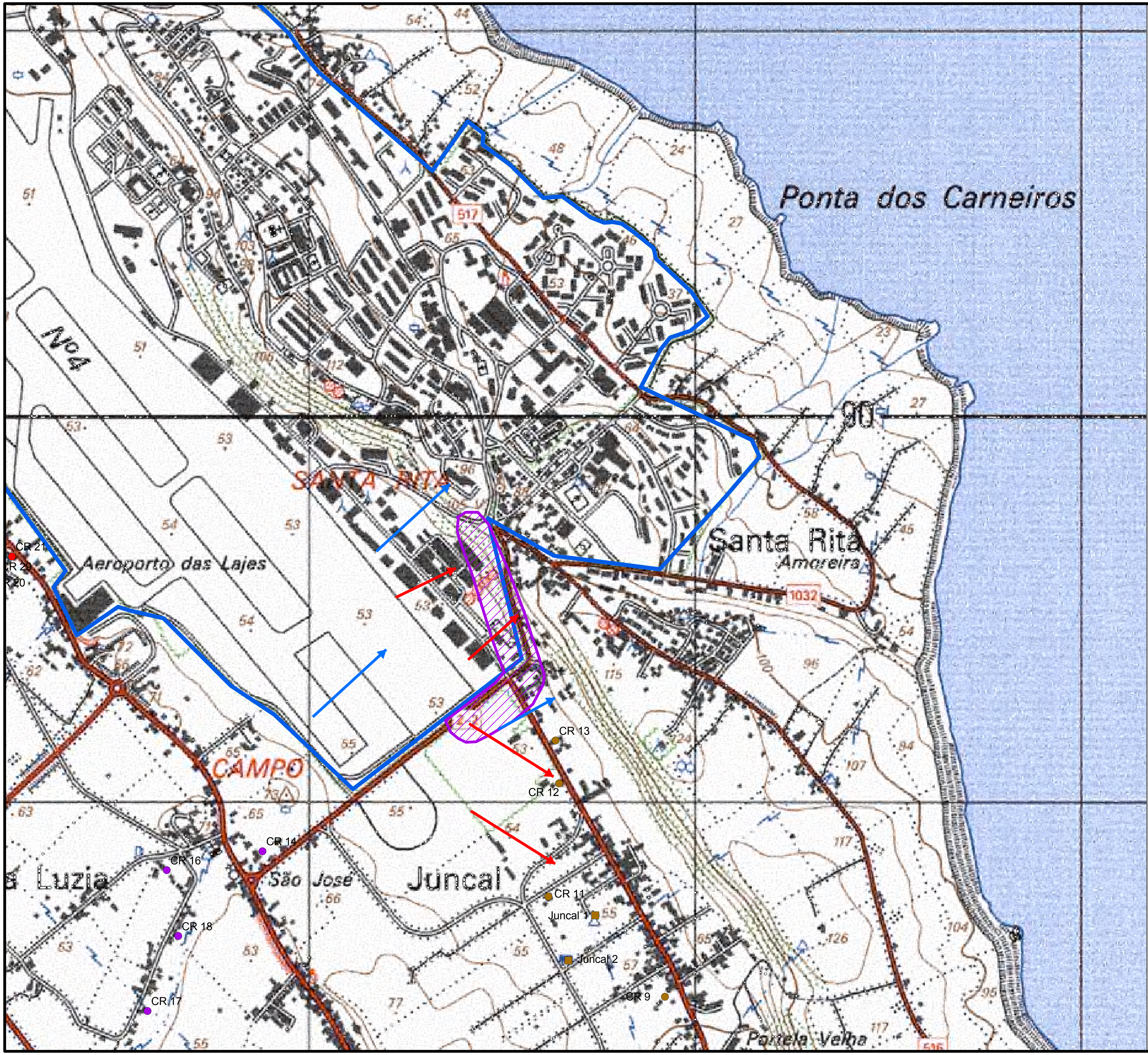

LEGEND

- AREA FOR WELLS IN THE BASAL AQUIFER
- AREA FOR WELLS IN THE PERCHED AQUIFER
- AREA FOR WELLS IN THE BASAL AND PERCHED AQUIFER
- LAJES SPRING
- LAJES – BASE WELL
- LAJES – SHALLOW PRODUCTION WELL
- FONTINHAS – SHALLOW PRODUCTION WELL
- FONTINHAS – CITY OF PRAIA
- JUNCAL – SHALLOW PRODUCTION WELL
- JUNCAL – CITY OF PRAIA
- PRAIA – SHALLOW PRODUCTION WELL
- PRAIA – CITY OF PRAIA
- PAUL – SHALLOW PRODUCTION WELL
- SANTA LUZIA – SHALLOW PRODUCTION WELL
- S. BRAS – CITY OF PRAIA
- SOUTH TANK FARM MONITORING WELL
- LAJES FIELD
- MAIN GATE AND FIVE HYDRANT AREA
- SIMULATED GROUNDWATER FLOW DIRECTION – PERCHED
- SIMULATED GROUNDWATER FLOW DIRECTION – BASAL

FIGURE 6-4
SIMULATED GROUNDWATER FLOW DIRECTIONS IN THE VICINITY OF THE MAIN GATE/5 HYDRANT AREA
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

CH2MHILL

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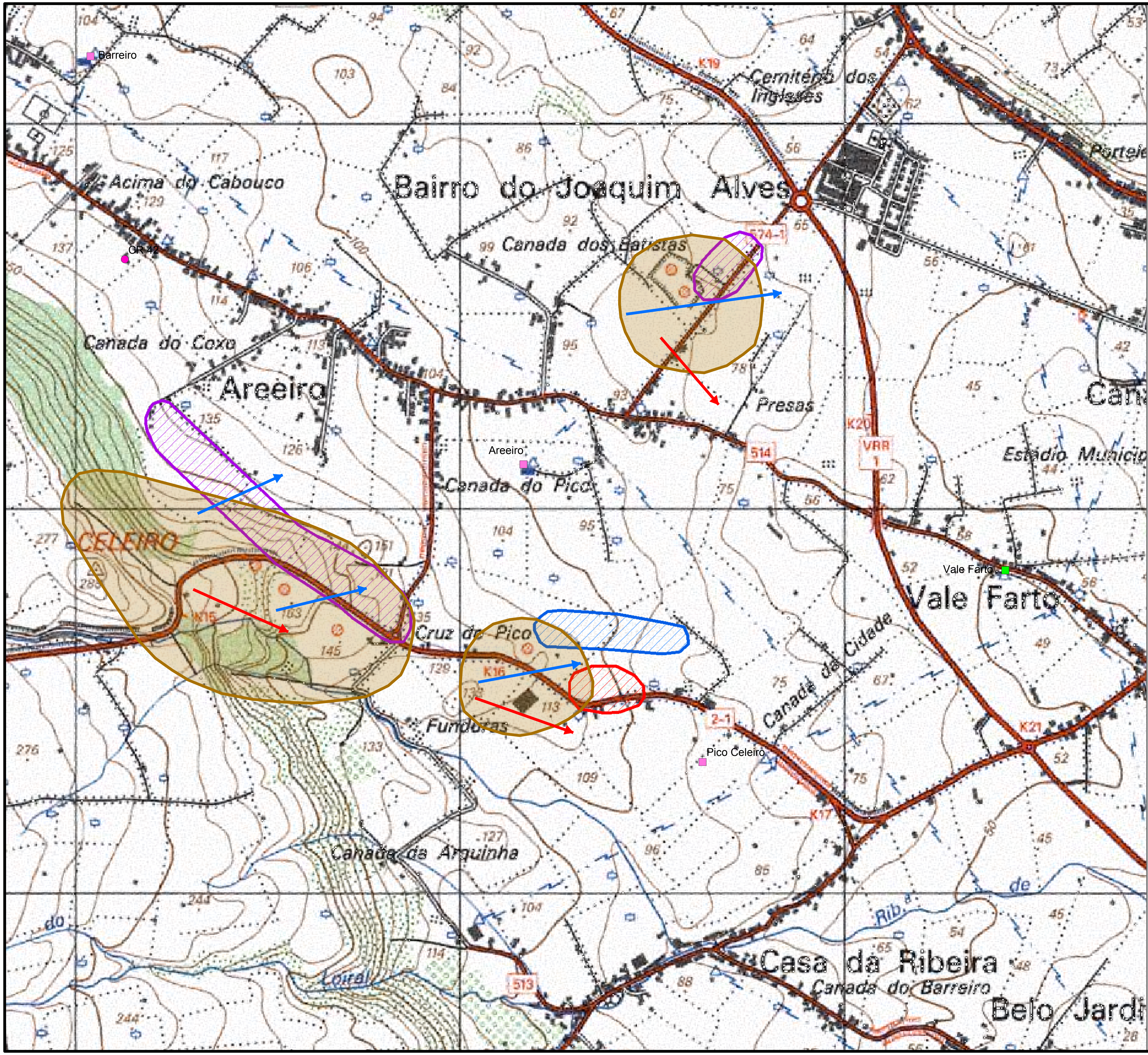

LEGEND

- LAJES SPRING
- LAJES – BASE WELL
- LAJES – SHALLOW PRODUCTION WELL
- FONTINHAS – SHALLOW PRODUCTION WELL
- FONTINHAS – CITY OF PRAIA
- JUNCAL – SHALLOW PRODUCTION WELL
- JUNCAL – CITY OF PRAIA
- PRAIA – SHALLOW PRODUCTION WELL
- PRAIA – CITY OF PRAIA
- PAUL – SHALLOW PRODUCTION WELL
- SANTA LUZIA – SHALLOW PRODUCTION WELL
- S. BRAS – CITY OF PRAIA
- SOUTH TANK FARM MONITORING WELL
- CINDER PIT FUEL TANKS
- AREA FOR WELLS IN THE BASAL AQUIFER
- AREA FOR WELLS IN THE PERCHED AQUIFER
- AREA FOR WELLS IN THE BASAL AND PERCHED AQUIFER
- SIMULATED GROUNDWATER FLOW DIRECTION – PERCHED
- SIMULATED GROUNDWATER FLOW DIRECTION – BASAL

N

0 250 500 meters

FIGURE 6-5
SIMULATED GROUNDWATER FLOW DIRECTIONS IN THE VICINITY OF THE CINDER PIT FUEL TANKS
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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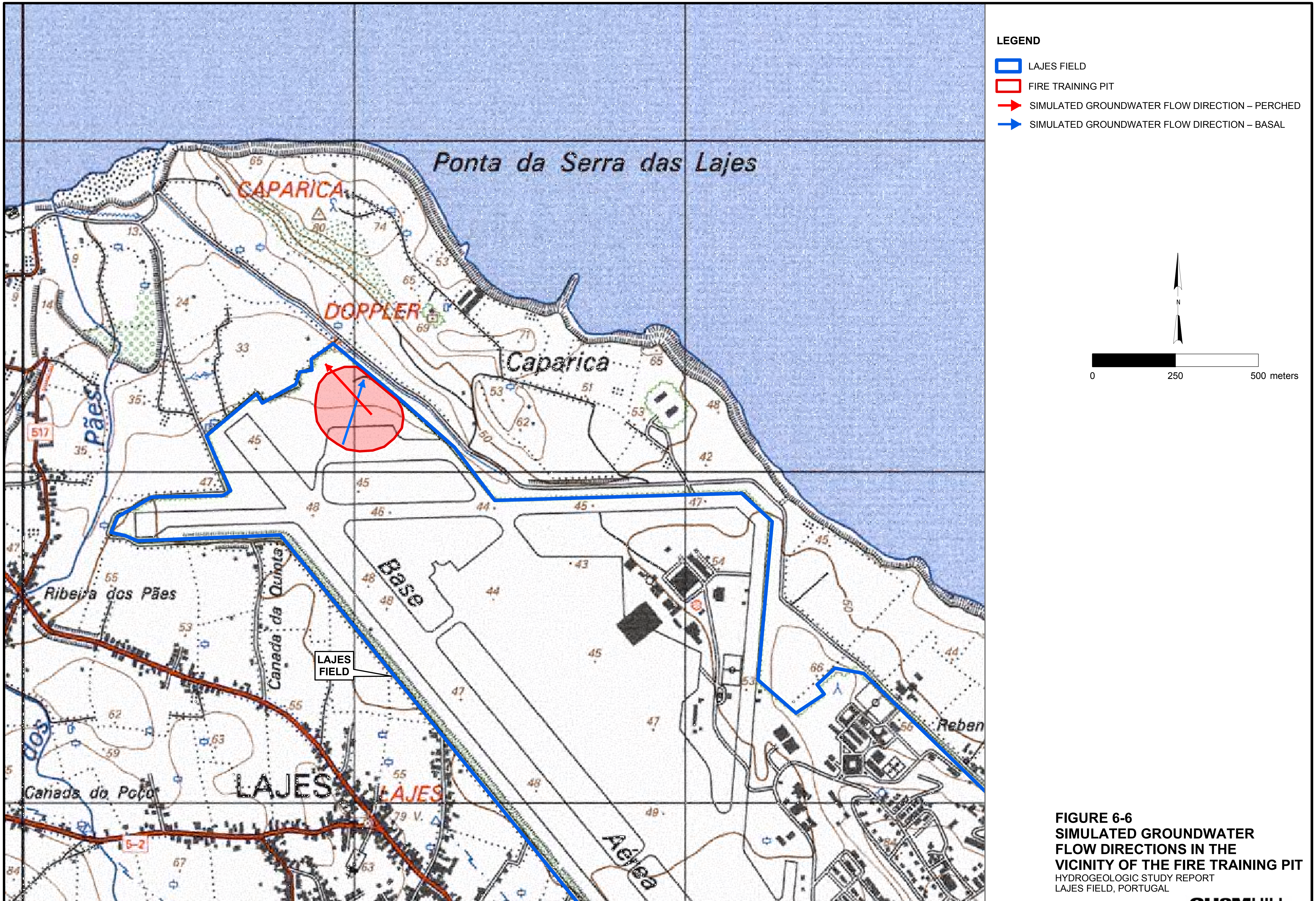
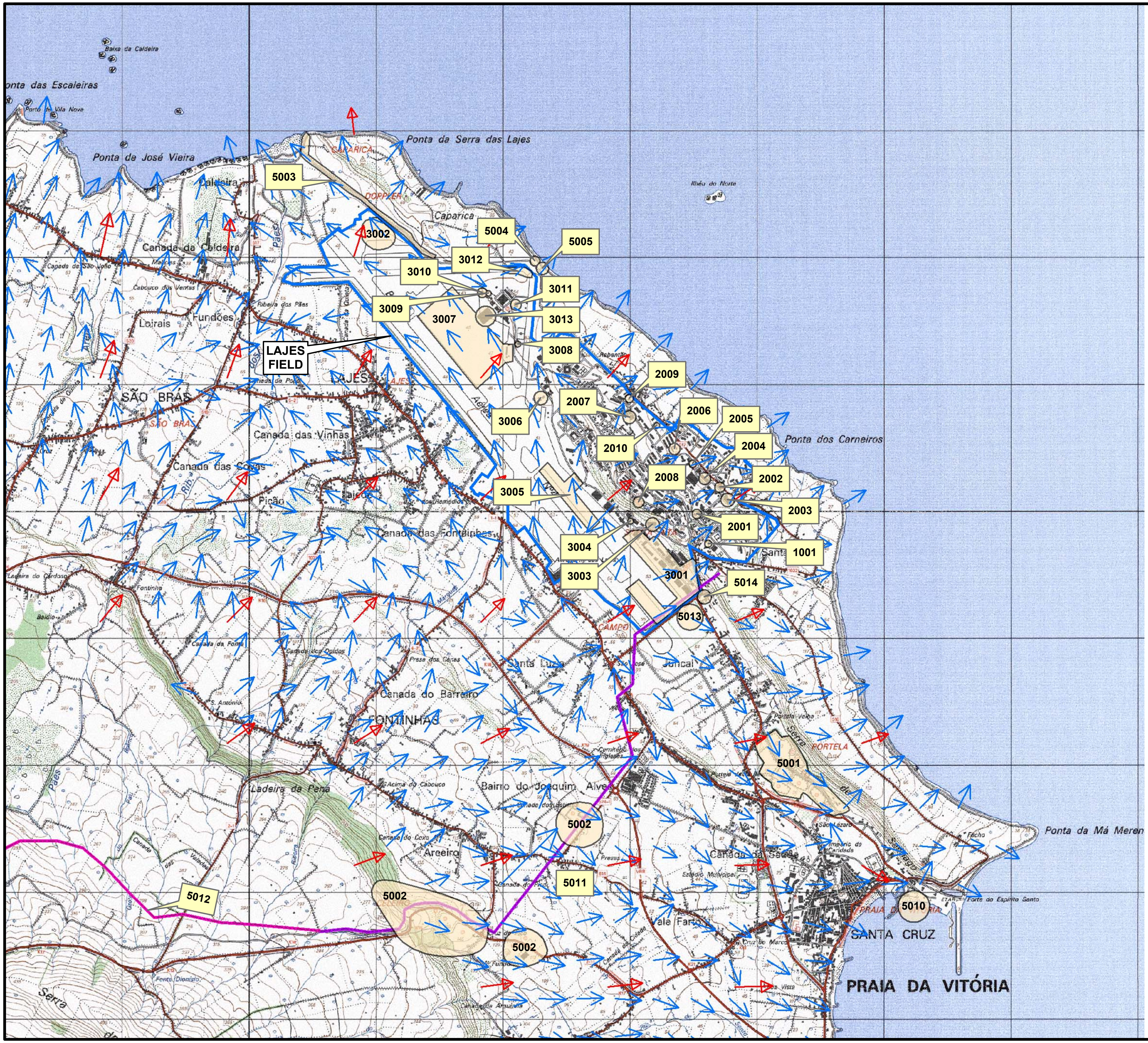


FIGURE 6-6
SIMULATED GROUNDWATER FLOW DIRECTIONS IN THE VICINITY OF THE FIRE TRAINING PIT
HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

CH2MHILL



LEGEND

SIMULATED GROUNDWATER FLOW DIRECTION – BASAL AQUIFER

SIMULATED GROUNDWATER FLOW DIRECTION – PERCHED AQUIFER

DISCO SITES:

- SITE 1001 – YOUTH CENTER
- SITE 2001 – POWER PLANT NO. 2
- SITE 2002 – TRANSPORTATION MAINTENANCE SHOP
- SITE 2003 – TRANSPORTATION PAINT SHOP
- SITE 2004 – LAUNDRY/DRY CLEANING SHOP
- SITE 2005 – BX SERVICE STATION
- SITE 2006 – AUTO HOBBY SHOP
- SITE 2007 – DRMO/MANNY'S GARAGE
- SITE 2008 – OLD PESTICIDE SHOP
- SITE 2009 – TRANSFORMER YARD
- SITE 2010 – FORMER MILSTAR POWER PLANT
- SITE 3001 – MAIN GATE/5 HYDRANT AREA
- SITE 3002 – FIRE TRAINING PIT
- SITE 3003 – MAIN POWER PLANT
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- SITE 3005 – 7 HYDRANTS AREA
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- SITE 3012 – ASBESTOS DUMP SITE
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- SITE 5005 – EOD AREA
- SITE 5010 – MEDIUM PORT COMMAND MAINTENANCE SHOP
- SITE 5013 – MILITARY HIGHWAY SPILL
- SITE 5014 – FORMER RUNNING TRACK

SITE 5011 – CINDER PIT PIPELINE

SITE 5012 – CABRITO PIPELINE

N

0 750 1,500 meters

FIGURE 6-7
SIMULATED GROUNDWATER FLOW DIRECTIONS IN THE VICINITY OF SUSPECTED CONTAMINATED SITES

HYDROGEOLOGIC STUDY REPORT
LAJES FIELD, PORTUGAL

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SECTION 7.0

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Appendix A
Well Canvass Report, VIVA 2004

LAJES FIELD HYDROGEOLOGIC STUDY – WELL CANVASS
Summary Table

WELL NAME	LOCATION	WELL DEPTH [m]	ELEVATION OF LAND SURFACE [m]	ELEVATION OF MEASURING POINT [m]	DEPTH TO STATIC WATER LEVEL [m]	FIELD ELEVATION [m]	COND [uS/cm]	TEMP [ºC]	UTM Coord graciosa E	UTM Coord graciosa N	UTM Coord WGS 84 E	UTM Coord WGS 84 N
LAJES FIELD WATER SUPPLY WELLS												
Well # 1 - T-1301	Lajes	73,760	59,049	59,194	57,710	1,484	468,000	22,700	491522,940	4289332,790	491625,801	4289248,196
Well # 2 - T-1302	Lajes	70,100	54,850	55,065	54,625	0,440	1030,000	22,300	491699,910	4289512,990	491802,843	4289428,395
Well # 3 - T-1303	Lajes	70,100	55,598	55,918	55,462	0,456	692,000	21,500	491755,180	4289730,740	491858,180	4289646,141
Well # 4 - T-1305	Lajes	73,150	56,792	57,299	56,762	0,537	736,000	22,200	491288,620	4289782,240	491391,564	4289697,634
Well # 5 - T-1306	Lajes	72,840	54,653	55,384	54,860	0,524	1000,000	22,000	491499,320	4289948,510	491602,341	4289863,903
Well # 8 - T-928	Lajes	57,910	51,636	51,833	51,490	0,343	1050,000	21,200	491775,760	4290257,300	491878,911	4290172,690
Well # 9 - T-1325	Lajes	85,510	71,650	71,805	72,540	-0,735	1130,000	24,600	490584,860	4289381,570	490687,605	4289296,963
Well # 10 - T-1326	Lajes	73,760	74,801	74,956			1170,000	24,100	490398,970	4289344,150	490501,682	4289259,542
Well - T-1112	Lajes	0,000	59,590	60,000			0,000	0,000	486995,000	4291929,000	487027,090	4291964,750
Well - T-1113	Lajes	0,000	102,854	103,234			0,000	0,000	486890,874	4291644,446	486993,641	4291559,744
SOUTH TANK FARM MONITORING WELLS												
MW04	Paul	10,962	30,205	30,134	10,482	19,652	0,000	0,000	494178,624	4288128,448	494281,541	4288043,914
MW08	Paul	5,655	5,000	4,793	4,595	0,198	557,000	20,200	494441,886	4287843,688	494544,763	4287759,164
MW09	Paul	4,350	2,396	2,259	1,971	0,288	582,000	19,500	494498,771	4287752,700	494601,631	4287668,179
MW10	Paul	5,345	3,245	3,088	2,698	0,390	460,000	21,800	494514,367	4287797,489	494617,241	4287712,967
MW17	Paul	4,690	1,984	1,878	1,532	0,346	1120,000	19,700	494571,525	4287729,755	494674,389	4287645,235
PRAIA DA VITORIA CITY HALL WATER SUPPLY WELLS												
Canada da Saúde	Praia	0,000	30,704	0,000	30,310	0,394	1418,000	23,000	493937,700	4287201,630	494040,349	4287117,113
Juncal 1	Juncal	62,700	55,289	0,000	56,000	-0,711	1839,000	23,000	493637,990	4288788,360	493741,011	4288703,805
Juncal 2	Juncal	64,800	53,189	0,000	52,893	0,296	6260,000	22,000	493568,660	4288671,090	493671,638	4288586,537
Vale Farto	Praia	0,000	48,483	0,000			0,000	0,000	493313,690	4286920,280	493416,202	4286835,762

LAJES FIELD HYDROGEOLOGIC STUDY – WELL CANVASS
Summary Table

WELL NAME	LOCATION	WELL DEPTH [m]	ELEVATION OF LAND SURFACE [m]	ELEVATION OF MEASURING POINT [m]	DEPTH TO STATIC WATER LEVEL [m]	FIELD ELEVATION [m]	COND [uS/cm]	TEMP [ºC]	UTM Coord graciosa E	UTM Coord graciosa N	UTM Coord WGS 84 E	UTM Coord WGS 84 N
PRAIA DA VITORIA CITY HALL WATER SUPPLY WELLS (continued)												
Areeiro - Fontinhas	Fontinhas	0,000	94,010	94,280			720,000	18,000	492060,860	4287195,646	492163,295	4287111,106
Pico Celeiro	Fontinhas	101,000	78,443	0,000			596,000	18,500	492526,550	4286421,560	492628,878	4286337,043
Fontinhas - Barreiro	Fontinhas	0,000	106,921	107,100			1204,000	21,000	490934,630	4288256,948	491037,164	4288172,370
Canada das Covas - Sao Bras	S. Bras	0,000	103,452	103,790	83,200	20,590	848,000	19,500	489050,795	4290139,077	489153,513	4290054,434
Private Wells												
CR 1	Paul	3,900	3,809	4,179	3,715	0,464	2300,000	19,500	494610,136	4287737,534	494713,007	4287653,014
CR 2	Paul	5,770	4,689	5,409	5,617	-0,208		0,000	494554,019	4287799,049	494656,899	4287714,527
CR 3	Paul	1,850	1,050	1,860	1,582	0,278	1398,000	19,500	494765,539	4287587,640	494868,391	4287503,126
CR 4	Paul	1,610	0,713	1,143	0,693	0,450	0,000	0,000	494766,760	4287620,900	494869,621	4287536,385
CR 5	Paul	6,900	5,735	6,565	5,720	0,845	969,000	20,000	494724,127	4287662,186	494826,993	4287577,669
CR 6	Praia	3,600	2,642	3,152	2,182	0,970	1255,000	19,000	494659,040	4287247,381	494761,790	4287162,873
CR 9	Juncal	11,420	56,205	56,965	8,563	48,402	1125,000	19,000	493818,948	4288577,710	493921,937	4288493,162
CR 11	Juncal	12,800	55,385	56,160	7,622	48,538	`	0,000	493516,866	4288837,271	493619,883	4288752,713
CR 12	Juncal	6,560	54,045	54,845	3,830	51,015	574,000	20,000	493544,431	4289130,326	493647,536	4289045,762
CR 13	Juncal	5,450	54,095	54,815	2,710	52,105	841,000	20,000	493535,007	4289241,146	493638,143	4289156,580
CR 14	Santa Luzia	11,740	65,487	66,137	10,080	56,057	1192,000	20,200	492776,000	4288954,306	492878,940	4288869,736
CR 16	Santa Luzia	30,000	65,213	65,973	19,328	46,645	424,000	18,000	492527,696	4288905,421	492630,588	4288820,849
CR 17	Santa Luzia	16,130	64,664	65,629	13,968	51,661	646,000	19,000	492478,189	4288540,417	492580,981	4288455,853
CR 18	Santa Luzia	18,450	63,895	64,750	17,080	47,670	798,000	18,000	492557,397	4288734,607	492660,249	4288650,039
CR 20	Lajes	17,450	63,536	64,361	14,190	50,171	984,000	20,000	492072,178	4289625,467	492175,197	4289540,874
CR 21	Lajes	17,730	62,369	63,269	13,490	49,779	907,000	18,000	492126,537	4289718,367	492229,590	4289633,773
CR 22	Lajes	47,550	55,717	56,722	35,490	21,232	398,000	18,000	490575,641	4291422,027	490678,932	4291337,376

LAJES FIELD HYDROGEOLOGIC STUDY – WELL CANVASS
Summary Table

WELL NAME	LOCATION	WELL DEPTH [m]	ELEVATION OF LAND SURFACE [m]	ELEVATION OF MEASURING POINT [m]	DEPTH TO STATIC WATER LEVEL [m]	FIELD ELEVATION [m]	COND [uS/cm]	TEMP [ºC]	UTM Coord graciosa E	UTM Coord graciosa N	UTM Coord WGS 84 E	UTM Coord WGS 84 N
PRIVATE WELLS (continued)												
CR 23	Lajes	20,230	45,799	46,599	16,290	30,309		0,000	489757,389	4291864,333	489860,668	4291779,662
CR 25	Lajes	15,100	55,362	55,982	11,560	44,422	860,000	18,000	491248,607	4290703,422	491351,801	4290618,795
CR 27	Lajes	17,000	57,439	58,209	13,580	44,629	796,000	18,500	491534,214	4290217,720	491637,315	4290133,107
CR 28	Lajes	35,690	61,064	61,904	31,290	30,614	580,000	20,500	490637,561	4290371,029	490740,564	4290286,402
CR 29	Lajes	19,750	64,613	65,373	15,863	49,510	998,000	18,000	492089,113	4289666,977	492192,146	4289582,383
CR 31	Lajes	14,740	59,518	60,268	11,772	48,496		0,000	491887,455	4289842,350	491990,506	4289757,750
CR 32	Lajes	14,460	62,581	63,321	11,559	51,762	616,000	18,000	491927,376	4289620,918	492030,372	4289536,323
CR 33	Lajes	15,740	60,273	61,153	12,920	48,233	0,000	0,000	491877,150	4289722,368	491980,166	4289637,770
CR 34	Lajes	15,330	57,360	58,380	1,765	56,615	915,000	18,000	491841,212	4289954,412	491944,287	4289869,809
CR 35	Lajes	23,950	58,682	59,572	22,897	36,675	634,000	19,500	491793,010	4290111,256	491896,122	4290026,649
CR 37	Lajes	15,460	57,552	58,317	15,360	42,957	685,000	18,500	491393,562	4290205,546	491496,637	4290120,932
CR 38	Lajes	13,760	55,825	56,600	12,360	44,240	420,000	19,000	491264,730	4290668,768	491367,916	4290584,142
CR 41	Lajes	31,600	48,253	49,023	30,177	18,846		0,000	489967,308	4291664,965	490070,565	4291580,301
CR 42	Fontinhas	21,290	135,150	136,050	20,020	116,030	372,000	18,000	491023,978	4287728,921	491126,412	4287644,356
CR 43	Fontinhas	9,530	125,800	126,625	9,090	117,535	258,000	18,000	490566,716	4288123,306	490669,180	4288038,726
CR 44	Fontinhas	13,500	132,276	133,121	12,110	121,011	395,000	18,000	490439,708	4288147,521	490542,163	4288062,939
CR 45	Fontinhas	14,530	137,237	137,682	11,890	125,792	394,000	18,500	489554,684	4288576,730	489657,129	4288492,128
CR 46	Fontinhas	13,670	137,133	137,883	11,620	126,263	249,000	18,000	489620,422	4288510,516	489722,861	4288425,916
CR 47	Praia	12,230	11,324	11,834	11,219	0,615	503,000	19,000	494067,511	4285657,511	494169,837	4285573,030
CR 48	Praia	3,700	2,569	3,169	2,482	0,687	1023,000	20,000	494435,016	4284999,812	494537,248	4284915,350
CR 49	Praia	3,700	3,640	3,650	3,550	0,100	2195,000	21,000	494458,463	4285624,839	494560,820	4285540,364
LAJES SPRING												
Lajes Spring	Lajes	0,000	15,062				495,000	19,500	489925,420	4292325,710	490028,870	4292241,032

Well Name Well # 1 – T-1301

Date: 2.Jul.2004
Time: 16:30

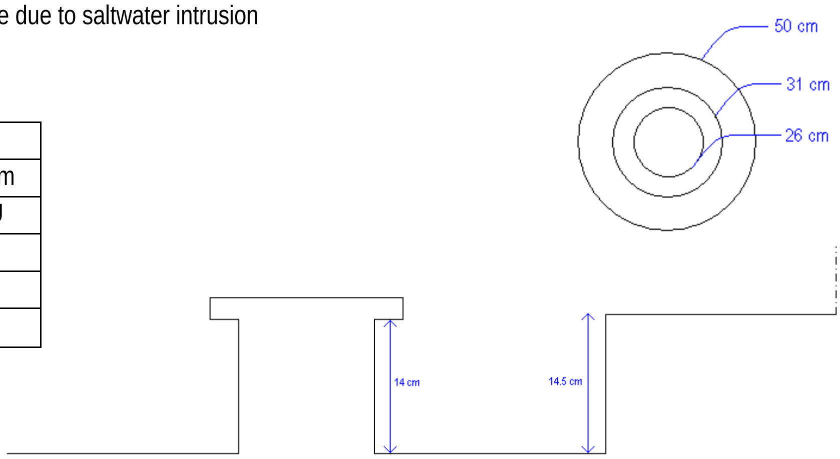
Use of well (domestic, abandoned, etc)	Water well	
Well Yield		
UTM coordinates – (real - out)	N=4289248.19627	E=491625.80125
Elevation of the land surface (real)	59.049 m	
Elevation of the measuring point	59.194 m	
Well depth	73.76 m	
Well diameter	12"	
Depth to Static Water Level	57.71 m	
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	drilled	
Type of well casing	steel	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

The well is considered abandoned for a period of time due to saltwater intrusion

Field Parameters:

pH =	7.41	
Cond.=	0.468	mS/cm
Turb=	64	NTU
DO=	0.67	Mg/l
Temperature =	22.7	ºC
Sal=	0.01	%



Pictures:

Well Name Well # 2 – T-1302

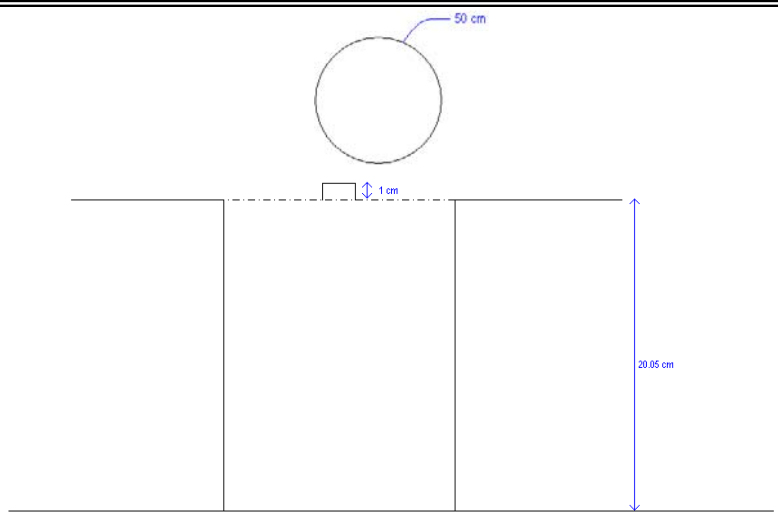
Date: 2.Jul.2004
Time: 16:20

Use of well (domestic, abandoned, etc)	Water well	
Well Yield		
UTM coordinates – (real-out)	N= 4289428.39462	E=491802.84337
Elevation of the land surface (real)	54.850 m	
Elevation of the measuring point	55.065 m	
Well depth	70.10 m	
Well diameter	12"	
Depth to Static Water Level	54.625 m	
Depth to pumping water level	55.063 m	
Well construction (Dug well, drilled well, etc)	drilled	
Type of well casing	steel	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	Submersible pump	
Pump size (impeller diameter, Horsepower, yield, etc)	Flow : 450 Gpd, 45 Hp. Chlorine pump 24 GPD Modelo: #B121-393B, seriel # 9802150500	
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Field Parameters:

pH =	7.06	
Cond.=	1.03	mS/cm
Turb=	0	NTU
DO=	0.08	Mg/l
Temperature =	22.3	ºC
Sal=	0.04	%



Pictures:

Well Name Well # 3 – T-1303

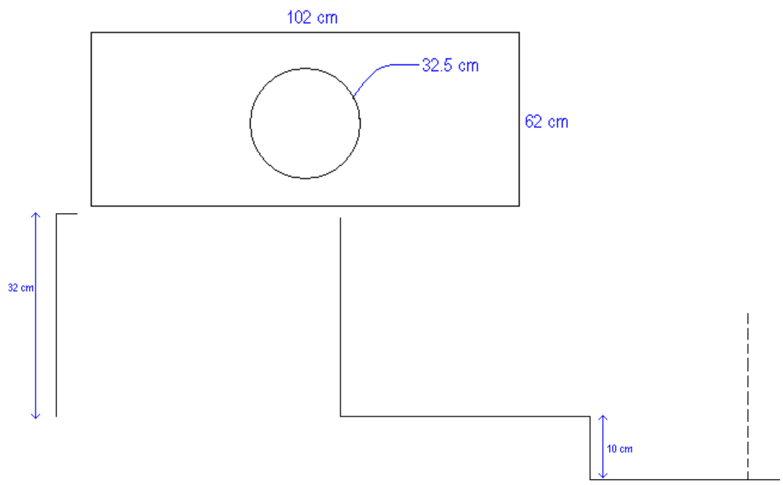
Date: 2.Jul.2004
Time: 14:40

Use of well (domestic, abandoned, etc)	Water well	
Well Yield		
UTM coordinates – (real- out)	N= 4289646.14062	E=491858.17994
Elevation of the land surface (real)	55.598 m	
Elevation of the measuring point	55.918 m	
Well depth	58.82 m	
Well diameter	12"	
Depth to Static Water Level	55.462 m	
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	drilled	
Type of well casing	steel	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Field Parameters:

pH =	7.08	
Cond.=	0.692	mS/cm
Turb=	0	NTU
DO=	0.14	Mg/l
Temperature =	21.5	ºC
Sal=	0.02	%



Pictures:

Well Name Well # 4 – T-1305

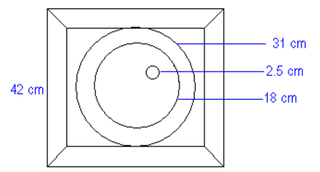
Date: 2.Jul.2004
Time: 13:50

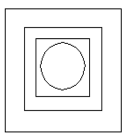
Use of well (domestic, abandoned, etc)	Water well	
Well Yield		
UTM coordinates – (real-out)	N= 4289697.63356	E=491391.56424
Elevation of the land surface (real)	56.792 m	
Elevation of the measuring point	57.299 m	
Well depth	73.15	
Well diameter	12"	
Depth to Static Water Level	56.762 m	
Depth to pumping water level	57.761 m	
Well construction (Dug well, drilled well, etc)	drilled	
Type of well casing	steel	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	Submersible pump	
Pump size (impeller diameter, Horsepower, yield, etc)	Diameter=6"; 30 Hp; Model # B121-393B; Chlorine pump = 24 GPD; flow = 250 GPM	
Water Quality Sample Results		
Electrical Conductance of Water		

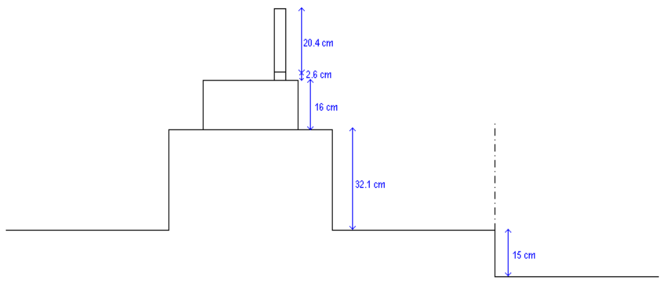
Obs:

Field Parameters:

pH =	7.31	
Cond.=	0.736	mS/cm
Turb=	0	NTU
DO=	0.16	Mg/l
Temperature =	22.2	ºC
Sal=	0.03	%







Pictures:

Well Name Well # 5 – T-1306

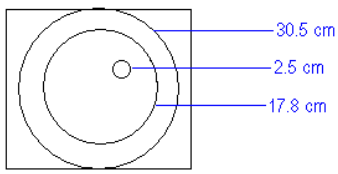
Date: 2.Jul.2004
Time: 14:20

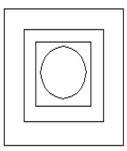
Use of well (domestic, abandoned, etc)	Water well	
Well Yield		
UTM coordinates – (real-out)	N= 4289863.90265	E=491602.34051
Elevation of the land surface (real)	54.653 m	
Elevation of the measuring point	55.384 m	
Well depth	72.84 m	
Well diameter	12"	
Depth to Static Water Level	54.86 m	
Depth to pumping water level	55.61 m	
Well construction (Dug well, drilled well, etc)	drilled	
Type of well casing	steel	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	Submersible pump	
Pump size (impeller diameter, Horsepower, yield, etc)	Diameter=6"; 25 Hp; Model # B121-393B; Chlorine pump = 24 GPD; flow = 220 GPM	
Water Quality Sample Results		
Electrical Conductance of Water		

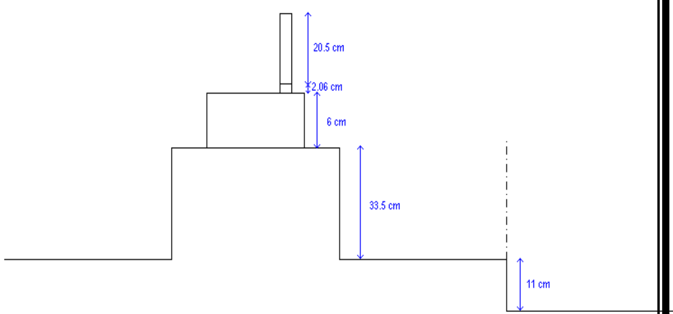
Obs:

Field Parameters:

pH =	7.00	
Cond.=	1.00	mS/cm
Turb=	0	NTU
DO=	0.10	Mg/l
Temperature =	22.0	ºC
Sal=	0.04	%







Pictures:

Well Name Well # 8 – T-928

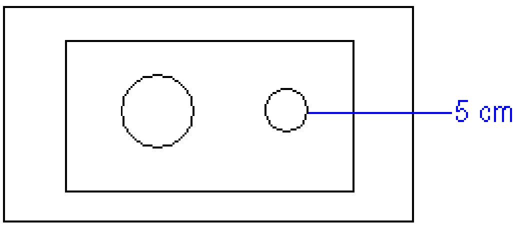
Date: 2.Jul.2004
Time: 10:30

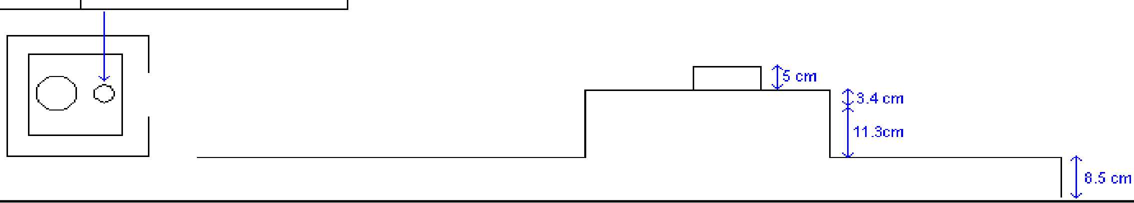
Use of well (domestic, abandoned, etc)	Water well	
Well Yield		
UTM coordinates – (real)	N= 4290172.68951	E=491878.91082
Elevation of the land surface (real)	51.636 m	
Elevation of the measuring point	51.833 m	
Well depth	57.91 m	
Well diameter	12"	
Depth to Static Water Level	51.482 m	
Depth to pumping water level	56.28 m	
Well construction (Dug well, drilled well, etc)	drilled	
Type of well casing	steel	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	Submersible pump	
Pump size (impeller diameter, Horsepower, yield, etc)	Diameter=4"; 30 Hp; Model # B121-393B; Chlorine pump = 24 GPD; flow = 250 GPM	
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Field Parameters:

pH =	7.00	
Cond.=	1.05	mS/cm
Turb=	0	NTU
DO=	0.99	Mg/l
Temperature =	21.2	ºC
Sal=	0.04	%





Pictures:

Well Name Well # 9 – T-1325

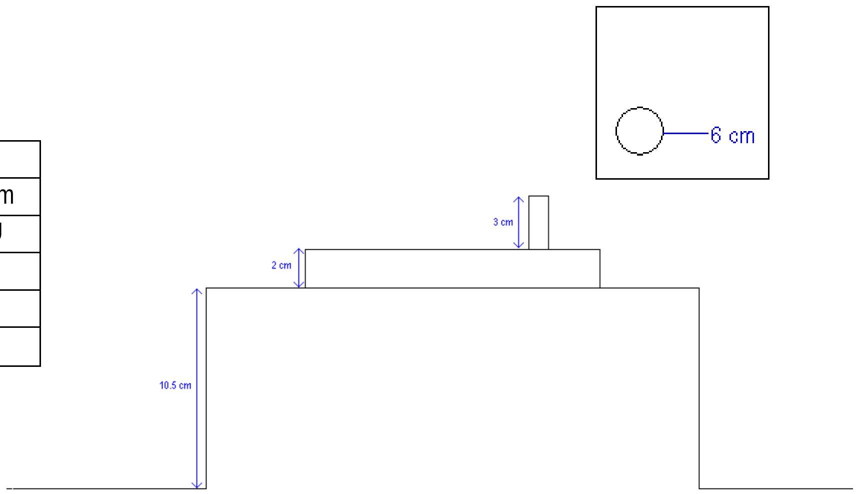
Date: 2.Jul.2004
Time:18:15

Use of well (domestic, abandoned, etc)	Water well	
Well Yield		
UTM coordinates – (real-out)	N= 4289296.96330	E=490687.60513
Elevation of the land surface (real)	71.650 m	
Elevation of the measuring point	71.805 m	
Well depth	85.51 m	
Well diameter	12"	
Depth to Static Water Level	72.54 m	
Depth to pumping water level	72.70 m	
Well construction (Dug well, drilled well, etc)	drilled	
Type of well casing	steel	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Field Parameters:

pH =	7.07	
Cond.=	1.13	mS/cm
Turb=	0	NTU
DO=	0.49	Mg/l
Temperature =	24.6	ºC
Sal=	0.05	%



Pictures:

Well Name Well # 10 – T-1326

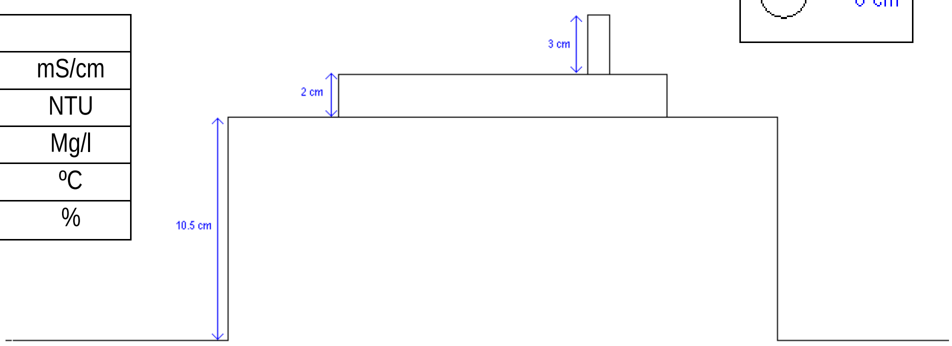
Date: 2.Jul.2004
Time: 17:30

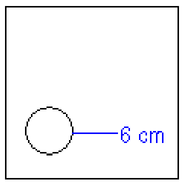
Use of well (domestic, abandoned, etc)	Water well	
Well Yield		
UTM coordinates – (real-out)	N= 4289259.54175	E=490501.68181
Elevation of the land surface (real)	74.801 m	
Elevation of the measuring point	74.956	
Well depth	84.42 m	
Well diameter	12"	
Depth to Static Water Level	74.06 m	
Depth to pumping water level	74.469 m	
Well construction (Dug well, drilled well, etc)	drilled	
Type of well casing	steel	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	submersible pump	
Pump size (impeller diameter, Horsepower, yield, etc)	flow 220 GPM	
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Field Parameters:

pH =	7.11	
Cond.=	1.17	mS/cm
Turb=	0	NTU
DO=	0.08	Mg/l
Temperature =	24.1	ºC
Sal=	0.05	%





Pictures:

Well Name Well # – T-1112 – Vila Nova Date: 23.Jul.2004

Use of well (domestic, abandoned, etc)	Water well –sealed	
Well Yield		
UTM coordinates (approximated)	N= 4291929	E= 486995
Elevation of the land surface (real)	59.590	
Elevation of the measuring point		
Well depth		
Well diameter		
Depth to Static Water Level		
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing		
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Temperature =
pH =

Time: 10:30
Date: 23.July.2004

Pictures:

Well Name Well # – T-1113 – Vila Nova2 Date: 28.Jul.2004

Use of well (domestic, abandoned, etc)	Water well – not active	
Well Yield		
UTM coordinates – (real)	N= 4291559.74379	E=486993.64147
Elevation of the land surface (real)	102.854 m	
Elevation of the measuring point	103.234 m	
Well depth		
Well diameter		
Depth to Static Water Level		
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing		
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	No Pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Probable water intrusion at 60.5 m

Temperature =
pH =

Time: 15:06
Date: 28.July.2004

Pictures:

Well Name MW 04

Date: 30.jun.2004
Time: 17:20 —18:30

Use of well (domestic, abandoned, etc)	Monitoring well	
Well Yield		
UTM coordinates – (real)	N= 4288043.91429	E= 494281.54090
Elevation of the land surface (real)	30.205 m	
Elevation of the measuring point	30.134 m	
Well depth	10.962 m	
Well diameter	Out = 21.0 cm	in = 5.0 cm
Depth to Static Water Level	10.482 m (12:20PM)	
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Drilled	
Type of well casing	Pvc	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	Submersible Whale-pump and hose (used in field)	
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

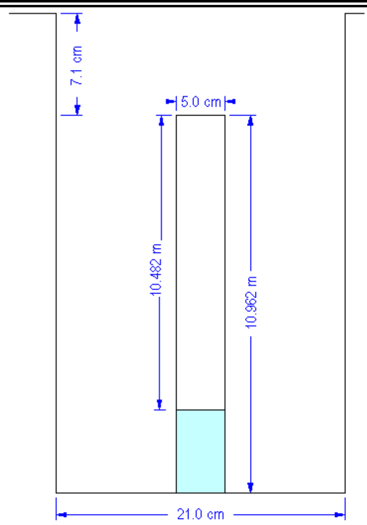
Obs:

Location: located to the right side of the access road to tank T-1636

It was not possible to measure the field parameters since not enough water in well

Field Parameters:

pH =	--
Cond.=	--
Turb=	--
DO=	--
Temperature =	--
Sal=	--



Pictures:

Well Name MW 08

Date: 30.jun.2004
Time: 16:40 – 17:20

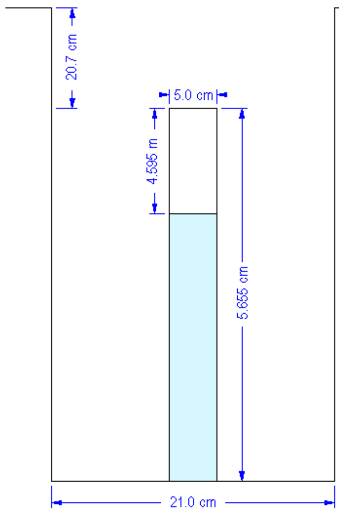
Use of well (domestic, abandoned, etc)	Monitoring well	
Well Yield		
UTM coordinates – (real)	N= 4287759.16385	E= 494544.76258
Elevation of the land surface (real)	5.000 m	
Elevation of the measuring point	4.793 m	
Well depth	5.655m	
Well diameter	Out = 21.0 cm	in = 5.0 cm
Depth to Static Water Level	4.595m (12:12PM)	
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Drilled	
Type of well casing	Pvc	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	Submersible Whale-pump and hose (used in field)	
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Location: Located west of the access road towards former tank T-1622

Field Parameters:

pH =	7.81	
Cond.=	0.557	mS/cm
Turb=	75	NTU
DO=	6.26	Mg/l
Temperature =	20.2	ºC
Sal=	0.02	%



Pictures:

Well Name MW 09

Date: 30.jun.2004
Time: 16:20 – 16:40

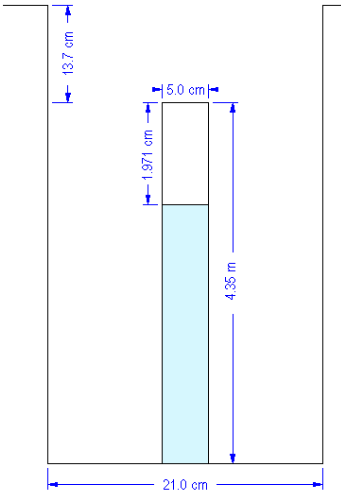
Use of well (domestic, abandoned, etc)	Monitoring well	
Well Yield		
UTM coordinates – (real)	N= 4287668.17856	E= 494601.63103
Elevation of the land surface (real)	2.396 m	
Elevation of the measuring point	2.259 m	
Well depth	4.35 m	
Well diameter	Out = 21.0 cm	in = 5.0 cm
Depth to Static Water Level	1.971 m (11:56 AM)	
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Drilled	
Type of well casing	Pvc	
Geologic log of well	Yes ☐ o	☐
Well construction log	Yes ☐ o	☐
Type of pump	Submersible Whale-pump and hose (used in field)	
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Location: Located on the left side of road, up gradient of the site OWS and fuel truck filling station

Field Parameters:

pH =	7.22	
Cond.=	0.582	mS/cm
Turb=	6	NTU
DO=	2.30	Mg/l
Temperature =	19.5	ºC
Sal=	0.02	%



Pictures:

Well Name MW 10

Date: 30.jun.2004
Time: 16:00 – 16:20

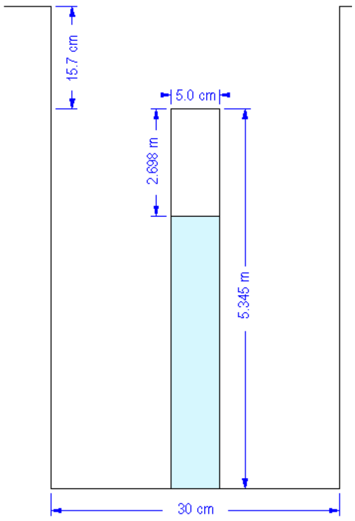
Use of well (domestic, abandoned, etc)	Monitoring well	
Well Yield		
UTM coordinates – (real)	N= 4287712.96679	E= 494617.24111
Elevation of the land surface (real)	3.245 m	
Elevation of the measuring point	3.088 m	
Well depth	5.345m	
Well diameter	Out = 30.0 cm	in = 5.0 cm
Depth to Static Water Level	2.698 m (12:03PM)	
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Drilled	
Type of well casing	Pvc	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	Submersible Whale-pump and hose (used in field)	
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

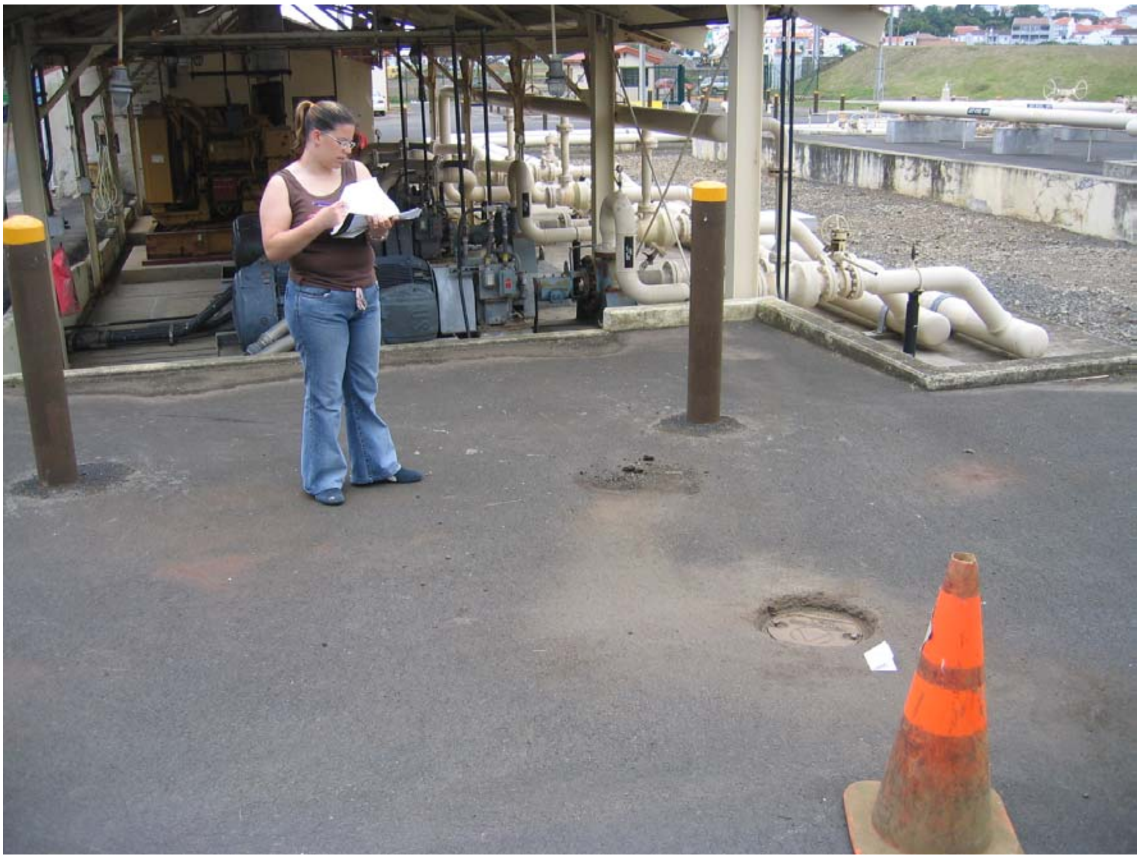
Location: Located in the asphalt paved area south of building T-1631

Field Parameters:

pH =	6.68	
Cond.=	0.460	mS/cm
Turb=	4	NTU
DO=	1.91	Mg/l
Temperature =	21.8	ºC
Sal=	0.01	%



Pictures:



Well Name MW 17

Date: 30.jun.2004
Time: 15:00 – 16:00

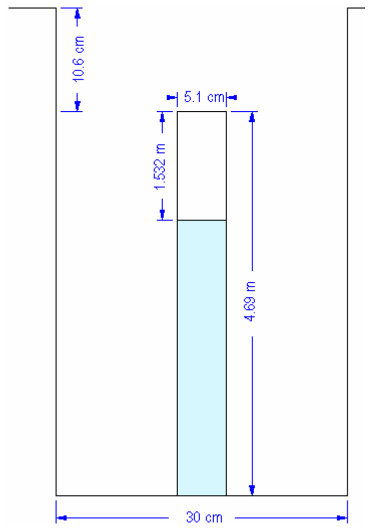
Use of well (domestic, abandoned, etc)	Monitoring well	
Well Yield		
UTM coordinates – (real)	N= 4287645.23499	E= 494674.38879
Elevation of the land surface (real)	1.984 m	
Elevation of the measuring point	1.878 m	
Well depth	4.69 m	
Well diameter	Out = 30.0 cm	in = 5.1 cm
Depth to Static Water Level	1.532 m (11:20 AM)	
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Drilled	
Type of well casing	Pvc	
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump	Submersible Whale-pump and hose (used in field)	
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Location: Located in the lowest portion of the site at the southern fenceline

Field Parameters:

pH =	7.08	
Cond.=	1.12	mS/cm
Turb=	150	NTU
DO=	0.76	Mg/l
Temperature =	19.7	ºC
Sal=	0.05	%



Pictures:

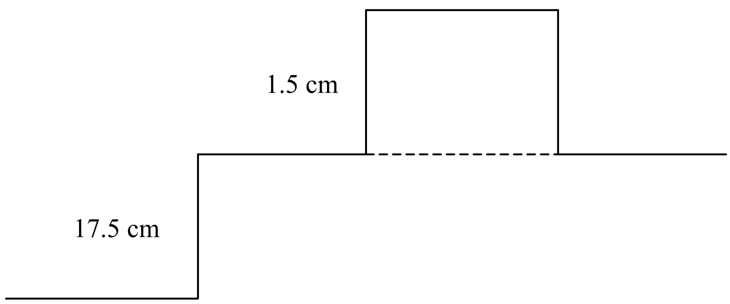
Well Name City Hall – Canada da Saúde **Date:** 13-Jul-2004

Use of well (domestic, abandoned, etc)	In use	
Well Yield		
UTM coordinates – (real - out)	N=4287117.11342	E=494040.34911
Elevation of the land surface (real)	30.514 m	
Elevation of the measuring point	30.704 m	
Well depth		
Well diameter	5 cm	
Depth to Static Water Level	30.310 m	Time:10:35
Depth to pumping water level	30.343 m	
Well construction (Dug well, drilled well, etc)		
Type of well casing	Steel casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 1418 mS/cm

Temp. = 22 º C

Time: 10:40
Date: 13 Jul 2004



Obs:

Pictures

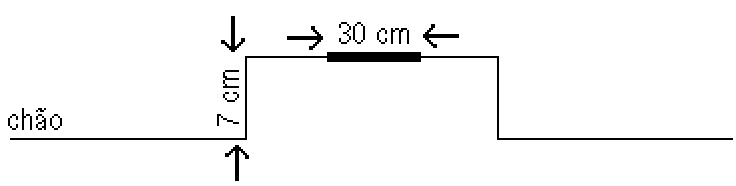
Well Name City Hall – Juncal 1 **Date:** 13-Jul-2004

Use of well (domestic, abandoned, etc)	In use	
Well Yield		
UTM coordinates – (real – out)	N= 4288703.80504	E=493741.01122
Elevation of the land surface (real)	55.219 m	
Elevation of the measuring point	55.289 m	
Well depth		
Well diameter	30 cm	
Depth to Static Water Level		Time:
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing	Steel casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 1839 mS/cm

Temp. = 23 º C

Time: 10:20
Date: 13 Jul 2004



Obs: It was not possible to measure the well depth until 10:30.

Pictures

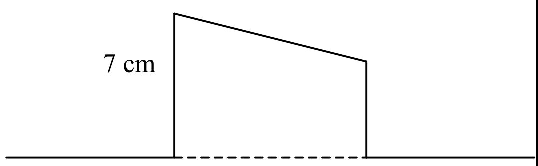
Well Name City Hall – Juncal 2 – Estrada Militar **Date:** 13-Jul-2004

Use of well (domestic, abandoned, etc)	Deactivated	
Well Yield		
UTM coordinates – (real - out)	N= 4288586.53670	E=493671.63829
Elevation of the land surface (real)	53.119 m	
Elevation of the measuring point	53.189 m	
Well depth		
Well diameter	17 cm	
Depth to Static Water Level	52.893 m	Time: 9:46
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing	Steel casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)	No active pump	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 6, 26 mS/cm

Temp. =22 º C

Time: 9:50
Date: 13 Jul 2004



Obs: permanenty out of use

Pictures

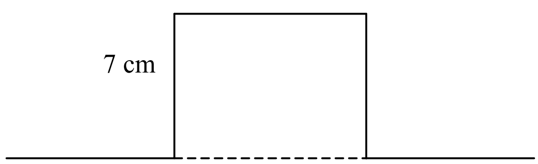
Well Name City Hall – Vale Farto **Date:** 13-Jul-2004

Use of well (domestic, abandoned, etc)	Deactivated	
Well Yield		
UTM coordinates – (real – out)	N=4286835.76163	E=493416.20244
Elevation of the land surface (real)	48.413 m	
Elevation of the measuring point	48.483 m	
Well depth		
Well diameter	- - -	
Depth to Static Water Level		Time:
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing	Steel casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. =

Temp. =

Time:
Date: 13 Jul 2004



Obs: It was not possible to take any measures because the well was covered with irons

Pictures

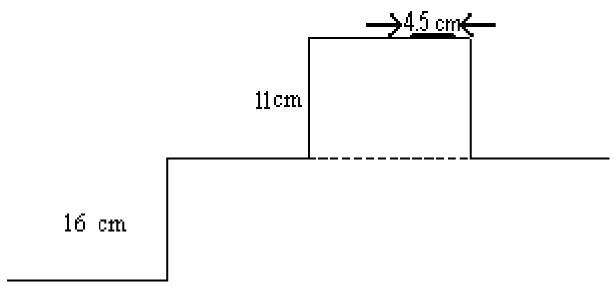
Well Name City Hall – Areeiro Fontinhas **Date:** 13-Jul-2004

Use of well (domestic, abandoned, etc)	In use	
Well Yield		
UTM coordinates – (real)	N= 4287111.10566	E=492163.29535
Elevation of the land surface (real)	94.01	
Elevation of the measuring point	94.28	
Well depth		
Well diameter	4.5 cm	
Depth to Static Water Level		Time:
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing	Steel casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 720 mS/cm

Temp. = 18 º C

Time: 11:05
Date: 13 Jul 2004



Obs: It was not possible to measure the well depth. The well cannot be stopped and we went to 150 m and did not found water.

Pictures

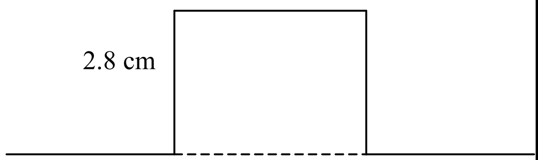
Well Name City Hall – Pico Celeiro **Date:** 13-Jul-2004

Use of well (domestic, abandoned, etc)	In use	
Well Yield		
UTM coordinates – (real - out)	N= 4286337.04256	E=492628.87773
Elevation of the land surface (real)	78.415 m	
Elevation of the measuring point	78.443 m	
Well depth		
Well diameter	5 cm	
Depth to Static Water Level		Time:
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing	Steel casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 596 mS/cm

Temp. = 18.5 ºC

Time:
Date: 13 Jul 2004



Obs: It was not possible to measure the well depth

Pictures

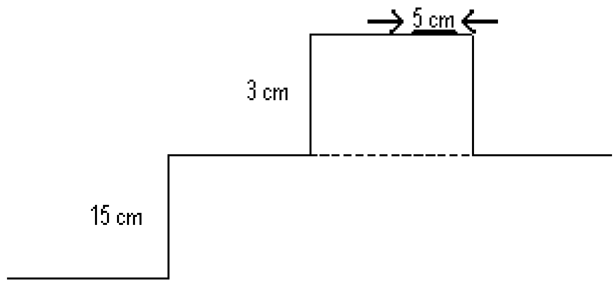
Well Name City Hall – Barreiro Fontinhas **Date:** 13-Jul-2004

Use of well (domestic, abandoned, etc)	In use	
Well Yield		
UTM coordinates – (real)	N= 4288172.37018	E=491037.16392
Elevation of the land surface (real)	106.921 m	
Elevation of the measuring point	107.101 m	
Well depth		
Well diameter	5 cm	
Depth to Static Water Level		Time:
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing	Steel casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. =1204 mS/cm

Temp. = 21 º C

Time: 15:50
Date: 13 Jul 2004



Obs: It was not possible to measure the well depth.

Pictures

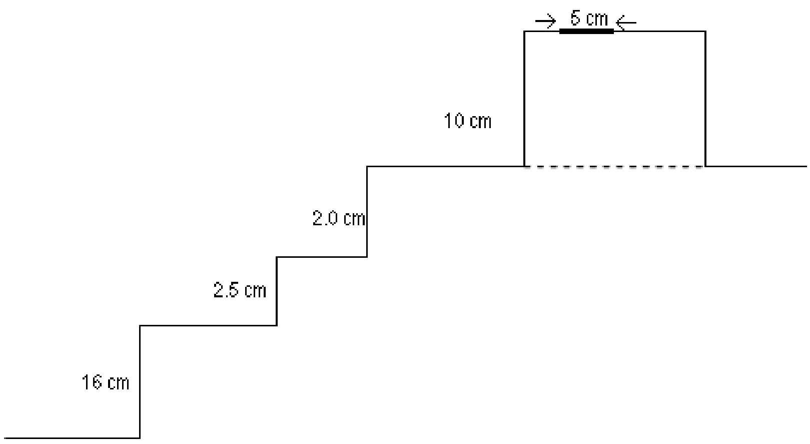
Well Name City Hall – Canada das Covas – São Bras **Date:** 13-Jul-2004

Use of well (domestic, abandoned, etc)	In use	
Well Yield		
UTM coordinates – (real)	N= 4290054.43447	E=489153.51348
Elevation of the land surface (real)	103.452	
Elevation of the measuring point	103.787	
Well depth	32 m	
Well diameter	5 cm	
Depth to Static Water Level	83.20 m	Time: 16:10
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing	Steel casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 848 mS/cm

Temp. =19.5 º C

Time: 15:50
Date: 13 Jul 2004



Obs: We found an escape at 32.57 m

Pictures

Well Name CR 1 Date: 12-Jul-2004

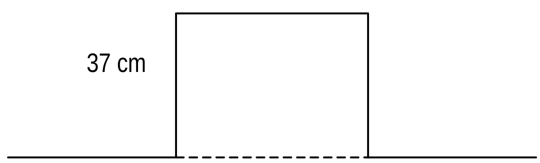
Use of well (domestic, abandoned, etc)	Farm land	
Well Yield		
UTM coordinates – (real)	N= 4287653.01432	E=494713.00712
Elevation of the land surface (real)	3.809 m	
Elevation of the measuring point	4.179 m	
Well depth	3.90 m	
Well diameter	> 1 m	
Depth to Static Water Level	3.715 m	Time: 10:30
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 2300 mS/cm

Temp. = 19.5ºC

Time: 10:35
Date: 12 Jul 2004

Obs:



Pictures:

Well Name CR 2 Date: 12-Jul-2004

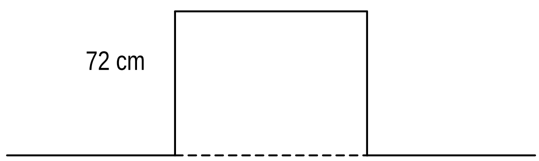
Use of well (domestic, abandoned, etc)	Farm land	
Well Yield		
UTM coordinates – (real)	N= 4287714.52726	E=494656.89896
Elevation of the land surface (real)	4.689 m	
Elevation of the measuring point	5.409 m	
Well depth	5.77 m	
Well diameter	> 1 m	
Depth to Static Water Level	5.617 m	Time: 10:45
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. =

Temp. =

Time:
Date:

Obs:



Pictures:

Well Name CR 3 Date: 12-Jul-2004

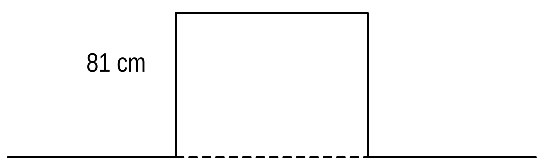
Use of well (domestic, abandoned, etc)	Farm land
Well Yield	
UTM coordinates – (real)	N= 4287503.12557 E= 494868.39114
Elevation of the land surface (real)	1.05 m
Elevation of the measuring point	1.860 m
Well depth	1.85 m
Well diameter	> 1 m
Depth to Static Water Level	1.582 m Time: 10:55
Depth to pumping water level	- - -
Well construction (Dug well, drilled well, etc)	Dug well
Type of well casing	No casing
Geologic log of well	Yes ☐ No ☐
Well construction log	Yes ☐ No ☐
Type of pump	No pump installed
Pump size (impeller diameter, Horsepower, yield, etc)	- - -
Water Quality Sample Results	
Electrical Conductance of Water	

Conduc. = 1398 mS/cm

Temp. = 19.5ºC

Time: 11:00
Date: 12 Jul 2004

Obs:



Pictures:

Well Name CR 4 Date: 12-Jul-2004

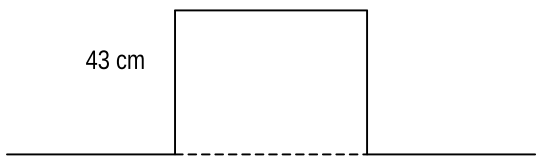
Use of well (domestic, abandoned, etc)	Domestic – out of use	
Well Yield		
UTM coordinates – (real)	N= 4287536.38486	E= 494869.62118
Elevation of the land surface (real)	0.713 m	
Elevation of the measuring point	1.143 m	
Well depth	1.61 m	
Well diameter	> 1 m	
Depth to Static Water Level	0.693 m	Time: 11:15
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	masonry	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. =

Temp. =

Time:
Date:

Obs:



Pictures:

Well Name CR 5 Date: 12-Jul-2004

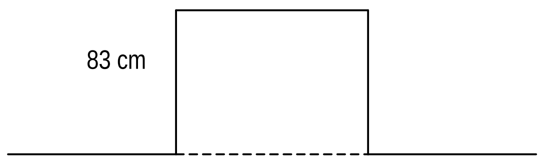
Use of well (domestic, abandoned, etc)	Domestic – out of use	
Well Yield		
UTM coordinates – (real)	N= 4287577.66942	E= 494826.99345
Elevation of the land surface (approximated)	7 m	
Elevation of the land surface (real)	5.735 m	
Elevation of the measuring point	6.565 m	
Well depth	6.90 m	
Well diameter	> 1 m	
Depth to Static Water Level	5.72 m	Time: 11:30
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 969 mS/cm

Temp. = 20 ºC

Time: 11:35
Date: 12 Jul 2004

Obs:



Pictures:

LAJES FIELD HYDROGEOLOGIC STUDY – WELL CANVASS
Private Wells

Well Name CR 6 Date: 12-Jul-2004

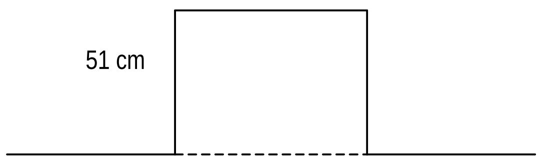
Use of well (domestic, abandoned, etc)	Domestic – out of use	
Well Yield		
UTM coordinates – (real)	N= 4287162.87264	E= 494761.78972
Elevation of the land surface (real)	2.642 m	
Elevation of the measuring point	3.152 m	
Well depth	3.6 m	
Well diameter	> 1 m	
Depth to Static Water Level	2.182 m	Time: 11:57
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	Masonry	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 1255 mS/cm

Temp. = 19 ^oC

Time: 12:00
Date: 12 Jul 2004

Obs:



Pictures:

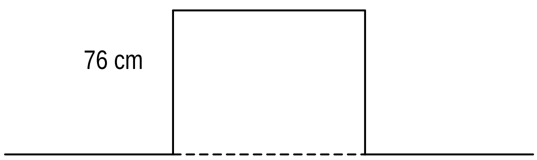
Well Name CR 9 Date: 12-Jul-2004

Use of well (domestic, abandoned, etc)	Active – farm land	
Well Yield		
UTM coordinates – (real)	N= 4288493.16193	E= 493921.93964
Elevation of the land surface (real)	56.205 m	
Elevation of the measuring point	56.965 m	
Well depth	11.42 m	
Well diameter	> 1 m	
Depth to Static Water Level	8.563 m	Time 14:18
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	Masonry	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 1125 mS/cm

Temp. = 19 ^{o}C

Time: 14:24
Date: 12 Jul 2004



Obs: With pump deactivated

Pictures:

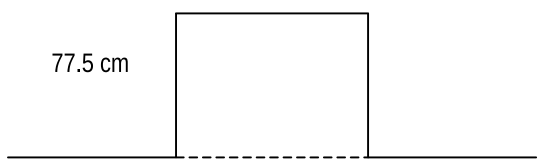
Well Name CR 11 Date: 12-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – Out of use
Well Yield	
UTM coordinates – (real)	N= 4288752.71343 | E= 493619.88294
Elevation of the land surface (real)	55.385 m
Elevation of the measuring point	56.160 m
Well depth	12.80 m
Well diameter	> 1 m
Depth to Static Water Level	7.622 | Time 15:10
Depth to pumping water level	- - -
Well construction (Dug well, drilled well, etc)	Dug well
Type of well casing	masonry
Geologic log of well	Yes ☐ No ☐
Well construction log	Yes ☐ No ☐
Type of pump	No pump installed
Pump size (impeller diameter, Horsepower, yield, etc)	- - -
Water Quality Sample Results	
Electrical Conductance of Water	

Conduc. =
Temp. =

Time:
Date:

Obs:



Pictures:

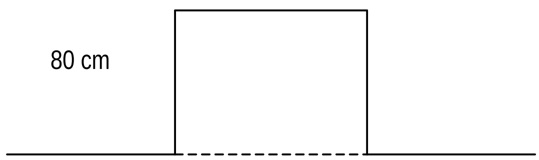
Well Name CR 12 Date: 12-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – Out of use	
Well Yield		
UTM coordinates – (real)	N= 4289045.76244	E= 493647.53582
Elevation of the land surface (real)	54.045 m	
Elevation of the measuring point	54.845 m	
Well depth	6.56 m	
Well diameter	> 1 m	
Depth to Static Water Level	3.83	Time 15:27
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	masonry	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 574 mS/cm
Temp. = 20 ºC

Time: 15:35
Date: 12 Jul 2004

Obs:



Pictures:

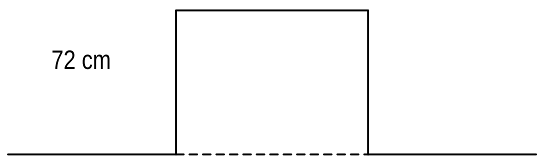
Well Name CR 13 Date: 12-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – Out of use	
Well Yield		
UTM coordinates – (real)	N= 4289156.57992	E= 493638.14274
Elevation of the land surface (real)	54.095 m	
Elevation of the measuring point	54.815 m	
Well depth	5.45 m	
Well diameter	> 1 m	
Depth to Static Water Level	2.71 m	Time 15:42
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	masonry	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 841 mS/cm
Temp. = 20ºC

Time: 15:55
Date: 12 Jul 2004

Obs:



Pictures:

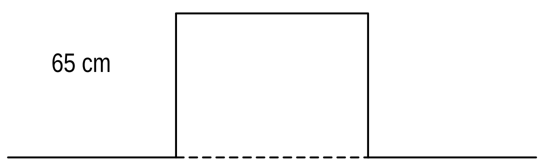
Well Name CR 14 Date: 12-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – abandoned	
Well Yield		
UTM coordinates – (real)	N= 4288869.73644	E= 492878.94048
Elevation of the land surface (real)	65.487 m	
Elevation of the measuring point	66.137 m	
Well depth	11.74 m	
Well diameter	> 1 m	
Depth to Static Water Level	10.08	Time 15:58
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	masonry	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 1192 mS/cm
Temp. = 20.2 ºC

Time: 16:10
Date: 12 Jul 2004

Obs:



Pictures:

Well Name CR 16 Date: 14-Jul-2004

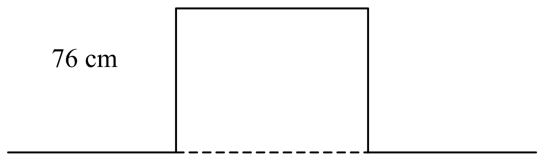
Use of well (domestic, abandoned, etc)	Domestic – Out of use
Well Yield	
UTM coordinates – (real)	N= 4288820.84933 | E= 492630.58805
Elevation of the land surface (real)	65.213 m
Elevation of the measuring point	65.973 m
Well depth	+/- 30 m
Well diameter	> 1 m
Depth to Static Water Level	19.328 | Time 11:25
Depth to pumping water level	- - -
Well construction (Dug well, drilled well, etc)	Dug well
Type of well casing	No casing
Geologic log of well	Yes ☐ No ☐
Well construction log	Yes ☐ No ☐
Type of pump	No pump installed
Pump size (impeller diameter, Horsepower, yield, etc)	- - -
Water Quality Sample Results	
Electrical Conductance of Water	

Conduc. = 424 mS/cm
Temp. = 18ºC

Time: 11:30
Date: 12 Jul 2004

Obs:

76 cm



Pictures:

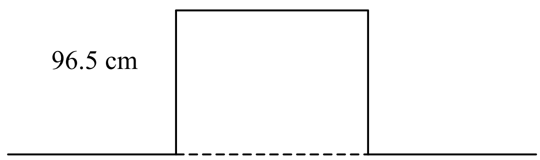
Well Name CR 17 Date: 14-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – Out of use		
Well Yield			
UTM coordinates – (real)	N= 4288455.85263	E= 492580.98061	
Elevation of the land surface (real)	64.664 m		
Elevation of the measuring point	65.629 m		
Well depth	16.13 m		
Well diameter	> 1 m		
Depth to Static Water Level	13.968	Time	12:00
Depth to pumping water level	- - -		
Well construction (Dug well, drilled well, etc)	Dug well		
Type of well casing	No casing		
Geologic log of well	Yes ☐ No ☐		
Well construction log	Yes ☐ No ☐		
Type of pump	No pump installed		
Pump size (impeller diameter, Horsepower, yield, etc)	- - -		
Water Quality Sample Results			
Electrical Conductance of Water			

Conduc. = 646 mS/cm
Temp. = 19ºC

Time: 12:05
Date: 14 Jul 2004

Obs:



Pictures:

LAJES FIELD HYDROGEOLOGIC STUDY – WELL CANVASS
Private Wells

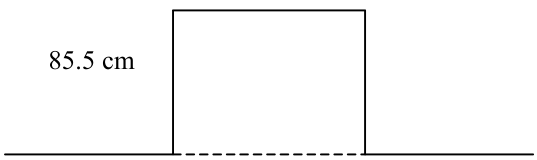
Well Name CR 18 Date: 14-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – Out of use	
Well Yield		
UTM coordinates – (real)	N= 4288650.03942	E= 492660.24874
Elevation of the land surface (real)	63.895 m	
Elevation of the measuring point	64.750 m	
Well depth	18.45 m	
Well diameter	> 1 m	
Depth to Static Water Level	17.08	Time 12:15
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 798 mS/cm
Temp. = 18ºC

Time: 12:20
Date: 14 Jul 2004

Obs:



Pictures:

Well Name CR 20 Date: 14-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use		
Well Yield			
UTM coordinates – (real)	N= 4289540.87393	E= 492175.19704	
Elevation of the land surface (real)	63.536 m		
Elevation of the measuring point	64.361m		
Well depth	17.45 m		
Well diameter	> 1 m		
Depth to Static Water Level	14.19 m	Time	14:47
Depth to pumping water level	- - -		
Well construction (Dug well, drilled well, etc)	Dug well		
Type of well casing	Masonry		
Geologic log of well	Yes ☐ No ☐		
Well construction log	Yes ☐ No ☐		
Type of pump	No pump installed		
Pump size (impeller diameter, Horsepower, yield, etc)	- - -		
Water Quality Sample Results			
Electrical Conductance of Water			

Conduc. = 948 mS/cm
Temp. = 20 ºC

Time: 15:00
Date: 14 Jul 2004

Obs: sewer in the next yard

Pictures:

Well Name CR 21 Date: 14-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use	
Well Yield		
UTM coordinates – (real)	N= 4289633.77261	E= 492229.59011
Elevation of the land surface (real)	62.369 m	
Elevation of the measuring point	63.269 m	
Well depth	17.73 m	
Well diameter	> 1 m	
Depth to Static Water Level	13.49 m	Time 15:00
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	Masonry	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 907 mS/cm
Temp. = 18 ºC

Time: 15:07
Date: 14 Jul 2004

Obs:

Pictures:

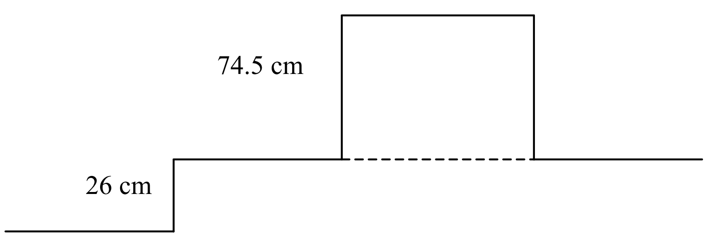
Well Name CR 22 Date: 14-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – abandoned	
Well Yield		
UTM coordinates – (real)	N= 4291337.37618	E= 490678.93235
Elevation of the land surface (real)	55.717 m	
Elevation of the measuring point	56.722 m	
Well depth	47.55 m	
Well diameter	> 1 m	
Depth to Static Water Level	35.49 m	Time 15:35
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 398 mS/cm
Temp. = 18 ºC

Time: 15:44
Date: 14 Jul 2004

Obs:



Pictures:

Well Name CR 23 Date: 14-Jul-2004

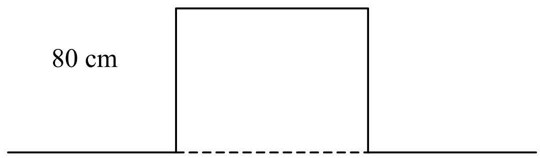
Use of well (domestic, abandoned, etc)	Domestic – out of use	
Well Yield		
UTM coordinates – (real)	N= 4291779.66231	E= 489860.66815
Elevation of the land surface (real)	45.799 m	
Elevation of the measuring point	46.599 m	
Well depth	20.23 m	
Well diameter	> 1 m	
Depth to Static Water Level	16.29 m	Time 15:58
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. =
Temp. =

Time:
Date:

Obs:

80 cm



Pictures:

LAJES FIELD HYDROGEOLOGIC STUDY – WELL CANVASS
Private Wells

Well Name CR 25 Date: 14-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use	
Well Yield		
UTM coordinates – (real)	N= 4290618.79519	E= 491351.80077
Elevation of the land surface (real)	55.362 m	
Elevation of the measuring point	55.982 m	
Well depth	15.10 m	
Well diameter	> 1 m	
Depth to Static Water Level	11.56 m	Time 17:30
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing ?	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 860 mS/cm
Temp. = 18ºC

Time: 17:33
Date: 14 Jul 2004

Obs:

Pictures:

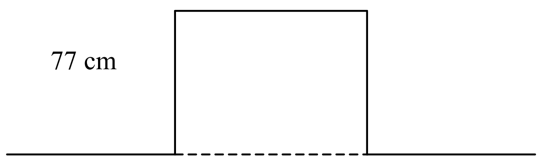
Well Name CR 27 Date: 15-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use	
Well Yield		
UTM coordinates – (real)	N= 4290133.10729	E= 491637.31476
Elevation of the land surface (real)	57.439 m	
Elevation of the measuring point	58.209 ,	
Well depth	17.00 m	
Well diameter	> 1 m	
Depth to Static Water Level	13:58	Time 11:28
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 796 mS/cm
Temp. = 18.5ºC

Time: 11:35
Date: 15 Jul 2004

Obs:



Pictures:

Well Name CR 28 Date: 15-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use
Well Yield	
UTM coordinates – (real)	N= 4290286.40158 E= 490740.56418
Elevation of the land surface (real)	61.064 m
Elevation of the measuring point	61.904 m
Well depth	35.69 m
Well diameter	> 1 m
Depth to Static Water Level	31.29 m Time 12:00
Depth to pumping water level	- - -
Well construction (Dug well, drilled well, etc)	Dug well
Type of well casing	No casing
Geologic log of well	Yes ☐ No ☐
Well construction log	Yes ☐ No ☐
Type of pump	No pump installed
Pump size (impeller diameter, Horsepower, yield, etc)	- - -
Water Quality Sample Results	
Electrical Conductance of Water	

Conduc. = 580 mS/cm
Temp. = 20.5ºC

Time: 12:06
Date: 15 Jul 2004

Obs:

Pictures:

Well Name CR 29 Date: 21-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use
Well Yield	
UTM coordinates – (real)	N= 4289582.38325 | E= 492192.14607
Elevation of the land surface (real)	64.613 m
Elevation of the measuring point	65.373 m
Well depth	19.75 m
Well diameter	> 1 m
Depth to Static Water Level	15.863 m | Time 11:35
Depth to pumping water level	- - -
Well construction (Dug well, drilled well, etc)	Dug well
Type of well casing	No casing
Geologic log of well	Yes ☐ No ☐
Well construction log	Yes ☐ No ☐
Type of pump	No pump installed
Pump size (impeller diameter, Horsepower, yield, etc)	- - -
Water Quality Sample Results	
Electrical Conductance of Water	

Conduc. = 998 mS/cm
Temp. = 18ºC

Time: 11:40
Date: 21 Jul 2004

Obs:

Pictures:

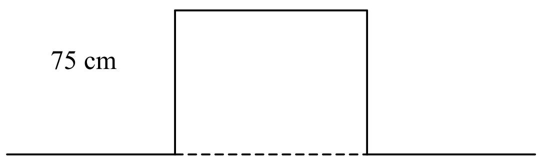
Well Name CR 31 Date: 21-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – sewer of washing machine	
Well Yield		
UTM coordinates – (real)	N= 4289757.74989	E= 491990.50582
Elevation of the land surface (real)	59.518 m	
Elevation of the measuring point	60.268 m	
Well depth	14.74 m	
Well diameter		
Depth to Static Water Level	11.772 m	Time 12:03
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. =
Temp. =

Time: 12:08
Date: 21 Jul 2004

Obs: It was not possible to take a sample of the water because we were not able to remove the wood.



Pictures:

LAJES FIELD HYDROGEOLOGIC STUDY – WELL CANVASS
Private Wells

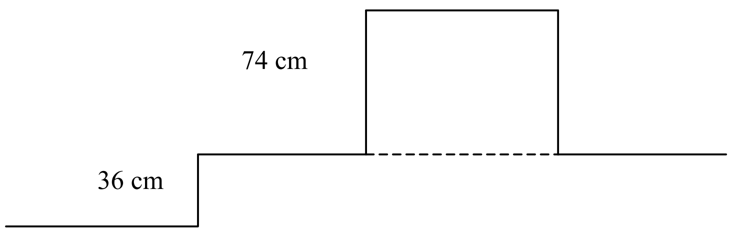
Well Name CR 32 Date: 21-Jul-2004

Use of well (domestic, abandoned, etc)	Farm land	
Well Yield		
UTM coordinates – (real)	N= 4289536.32318	E= 492030.37195
Elevation of the land surface (real)	62.581 m	
Elevation of the measuring point	63.321 m	
Well depth	14.46 m	
Well diameter	> 1 m	
Depth to Static Water Level	11.559	Time 12:11
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 616 mS/cm
Temp. = 18ºC

Time: 12:15
Date: 21 Jul 2004

Obs:



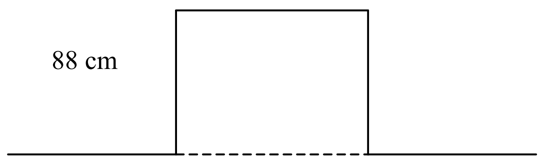
Pictures:

Well Name CR 33 Date: 21-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use	
Well Yield		
UTM coordinates – (real)	N= 4289637.77035	E= 491980.16609
Elevation of the land surface (real)	60.273 m	
Elevation of the measuring point	61.153 m	
Well depth	15.70 m	
Well diameter	> 1 m	
Depth to Static Water Level	12.92	Time 12:45
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. =
Temp. =

Time:
Date:



Obs: Covered with a net

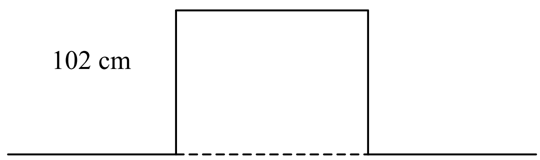
Pictures:

Well Name CR 34 Date: 21-Jul-2004

Use of well (domestic, abandoned, etc)	Farm land	
Well Yield		
UTM coordinates – (real)	N= 4289869.80888	E= 491944.28696
Elevation of the land surface (real)	57.360 m	
Elevation of the measuring point	58.380 m	
Well depth	15.33 m	
Well diameter	> 1 m	
Depth to Static Water Level	11.765	Time 13:00
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 915 mS/cm
Temp. = 18ºC

Time: 13:08
Date: 21 Jul 2004



Obs: There are pigs near the well

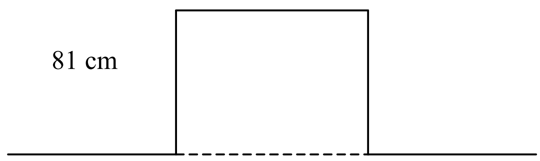
Pictures:

Well Name CR 35 **Date:** 21-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use
Well Yield	
UTM coordinates – (real)	N= 4290026.64888 E= 491896.12170
Elevation of the land surface (real)	58.682 m
Elevation of the measuring point	59.492 m
Well depth	23.95 m
Well diameter	> 1 m
Depth to Static Water Level	22.897 Time 14:15
Depth to pumping water level	- - -
Well construction (Dug well, drilled well, etc)	Dug well
Type of well casing	No casing
Geologic log of well	Yes ☐ No ☐
Well construction log	Yes ☐ No ☐
Type of pump	No pump installed
Pump size (impeller diameter, Horsepower, yield, etc)	- - -
Water Quality Sample Results	
Electrical Conductance of Water	

Conduc. = 634 mS/cm
Temp. = 19.5ºC

Time: 14:22
Date: 21 Jul 2004



Obs:

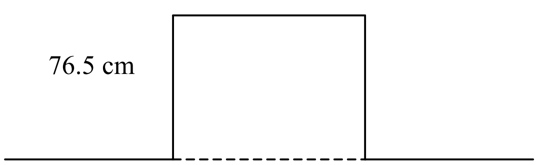
Pictures:

Well Name CR 37 Date: 21-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use – abandoned		
Well Yield			
UTM coordinates – (real)	N= 4290120.93176	E= 491496.63716	
Elevation of the land surface (real)	57.552 m		
Elevation of the measuring point	58.317 m		
Well depth	15.46 m		
Well diameter	> 1 m		
Depth to Static Water Level	15.36 m	Time	14:30
Depth to pumping water level	- - -		
Well construction (Dug well, drilled well, etc)	Dug well		
Type of well casing	No casing		
Geologic log of well	Yes ☐ No ☐		
Well construction log	Yes ☐ No ☐		
Type of pump	No pump installed		
Pump size (impeller diameter, Horsepower, yield, etc)	- - -		
Water Quality Sample Results			
Electrical Conductance of Water			

Conduc. = 685 mS/cm
Temp. = 18.5ºC

Time: 14:40
Date: 21 Jul 2004



Obs:

Pictures:

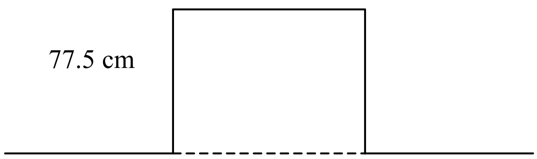
LAJES FIELD HYDROGEOLOGIC STUDY – WELL CANVASS
Private Wells

Well Name CR 38 Date: 21-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic – out of use	
Well Yield		
UTM coordinates – (real)	N= 4290584.14214	E= 491367.91635
Elevation of the land surface (real)	55.825 m	
Elevation of the measuring point	56.600 m	
Well depth	13.76 m	
Well diameter	> 1 m	
Depth to Static Water Level	12.36 m	Time 14:50
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. =420 mS/cm
Temp. = 19ºC

Time: 14:55
Date: 21 Jul 2004



Obs:

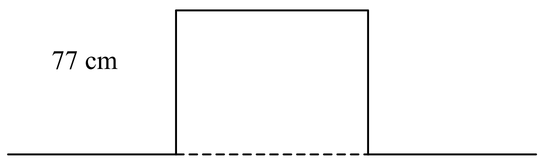
Pictures:

Well Name CR 41 Date: 21-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic –out of use	
Well Yield		
UTM coordinates – (real)	N= 4291580.30124	E= 490070.56519
Elevation of the land surface (real)	48.253 m	
Elevation of the measuring point	49.023 m	
Well depth	31.60 m	
Well diameter	> 1 m	
Depth to Static Water Level	30.177	Time 16:48
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. =
Temp. =

Time:
Date:



Obs: Covered with a net

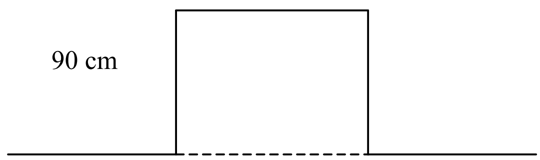
Pictures:

Well Name CR 42 Date: 22-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic –out of use	
Well Yield		
UTM coordinates – (real)	N= 4287644.35583	E= 491126.41182
Elevation of the land surface (real)	135.150 m	
Elevation of the measuring point	136.050 m	
Well depth	21.29 m	
Well diameter	> 1 m	
Depth to Static Water Level	20.02	Time 10:40
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 372 mS/cm
Temp. = 18ºC

Time: 14:36
Date: 22 Jul 2004



Obs:

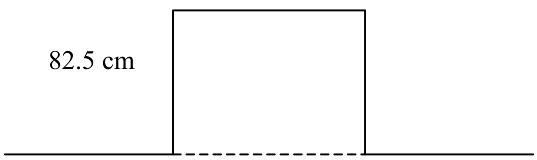
Pictures:

Well Name CR 43 Date: 22-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic –out of use	
Well Yield		
UTM coordinates – (real)	N= 4288038.72643	E= 490669.18044
Elevation of the land surface (real)	125.800 m	
Elevation of the measuring point	126.625 m	
Well depth	9.53 m	
Well diameter	> 1 m	
Depth to Static Water Level	9.09 m	Time 11:05
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 258 mS/cm
Temp. = 18ºC

Time: 11:00
Date: 22 Jul 2004



Obs:

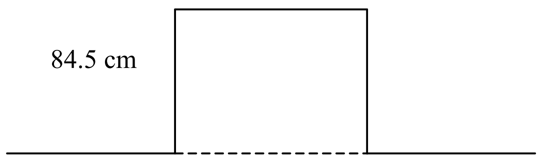
Pictures:

Well Name CR 44 Date: 22-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic –out of use		
Well Yield			
UTM coordinates – (real)	N= 4288062.93929	E= 490542.16343	
Elevation of the land surface (real)	132.276 m		
Elevation of the measuring point	133.121 m		
Well depth	13.50 m		
Well diameter	> 1 m		
Depth to Static Water Level	12.11	Time	11:16
Depth to pumping water level	- - -		
Well construction (Dug well, drilled well, etc)	Dug well		
Type of well casing	No casing		
Geologic log of well	Yes ☐ No ☐		
Well construction log	Yes ☐ No ☐		
Type of pump	No pump installed		
Pump size (impeller diameter, Horsepower, yield, etc)	- - -		
Water Quality Sample Results			
Electrical Conductance of Water			

Conduc. = 395mS/cm
Temp. = 18ºC

Time: 11:05
Date: 22 Jul 2004



Obs:

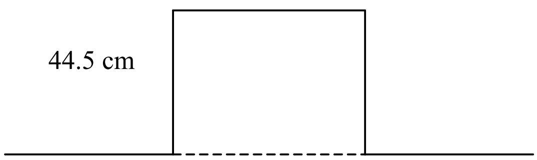
Pictures:

Well Name CR 45 Date: 22-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic –out of use	
Well Yield		
UTM coordinates – (real)	N= 4288492.12773	E= 489657.12867
Elevation of the land surface (real)	137.237 m	
Elevation of the measuring point	137.682 m	
Well depth	14.53 m	
Well diameter	> 1 m	
Depth to Static Water Level	11.89 m	Time 11:45
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 394mS/cm
Temp. = 18.5ºC

Time: 11:40
Date: 22 Jul 2004



Obs:

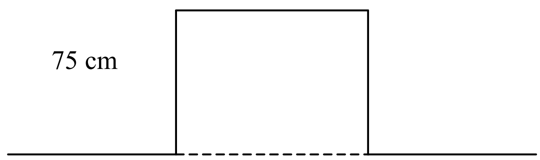
Pictures:

Well Name CR 46 **Date:** 22-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic –out of use – abandoned	
Well Yield		
UTM coordinates – (real)	N= 4288428.91600	E= 489722.86071
Elevation of the land surface (real)	137.133 m	
Elevation of the measuring point	137.883 m	
Well depth	13.67 m	
Well diameter	> 1 m	
Depth to Static Water Level	11.62 m	Time 11:57
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 249mS/cm
Temp. = 18ºC

Time: 12:00
Date: 22 Jul 2004



Obs: with steps in

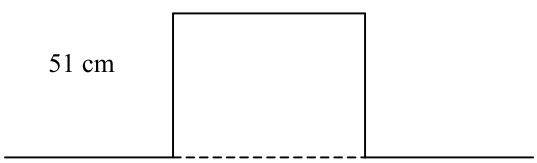
Pictures:

Well Name CR 47 Date: 22-Jul-2004

Use of well (domestic, abandoned, etc)	Domestic –out of use	
Well Yield		
UTM coordinates – (real)	N= 4285573.02998	E= 494169.83650
Elevation of the land surface (real)	11.324 m	
Elevation of the measuring point	11.834 m	
Well depth	12.23 m	
Well diameter	> 1 m	
Depth to Static Water Level	11.219 m	Time 12:21
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	With pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	It was not possible to know non of the characteristics if the pump	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 503mS/cm
Temp. = 19ºC

Time: 12:30
Date: 22 Jul 2004



Obs:

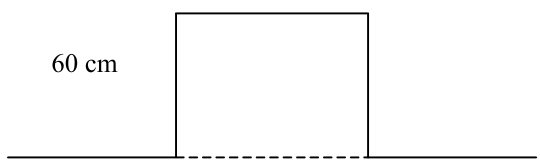
Pictures:

Well Name CR 48 Date: 22-Jul-2004

Use of well (domestic, abandoned, etc)	Farm land	
Well Yield		
UTM coordinates – (real)	N= 4284915.35018	E= 494537.24781
Elevation of the land surface (real)	2.569 m	
Elevation of the measuring point	3.169 m	
Well depth	3.70 m	
Well diameter	> 1 m	
Depth to Static Water Level	2.482 m	Time 12:31
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 1023mS/cm
Temp. = 20ºC

Time: 12:26
Date: 22 Jul 2004



Obs:

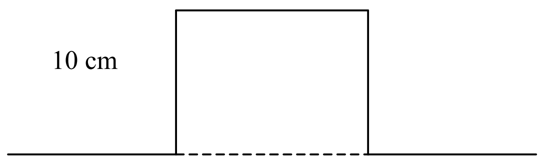
Pictures:

Well Name CR 49 Date: 22-Jul-2004

Use of well (domestic, abandoned, etc)	Farm land	
Well Yield		
UTM coordinates – (real)	N= 4285540.36368	E= 494560.81954
Elevation of the land surface (real)	3.640 m	
Elevation of the measuring point	3.650 m	
Well depth	3.70 m	
Well diameter	> 1 m	
Depth to Static Water Level	3.55 m	Time 14:13
Depth to pumping water level	- - -	
Well construction (Dug well, drilled well, etc)	Dug well	
Type of well casing	No casing	
Geologic log of well	Yes ☐ No ☐	
Well construction log	Yes ☐ No ☐	
Type of pump	No pump installed	
Pump size (impeller diameter, Horsepower, yield, etc)	- - -	
Water Quality Sample Results		
Electrical Conductance of Water		

Conduc. = 2195 mS/cm
Temp. = 21ºC

Time: 14:10
Date: 22 Jul 2004



Obs:

Pictures:

Well Name Lajes Spring Date: 21 Jul 2004

Use of well (domestic, abandoned, etc)	Spring	
Well Yield		
UTM coordinates – (real)	N= 4292241.03157	E= 490028.87046
Elevation of the measuring point	15.062 m	
Well depth		
Well diameter		
Depth to Static Water Level		
Depth to pumping water level		
Well construction (Dug well, drilled well, etc)		
Type of well casing		
Geologic log of well	Yes ☐ o ☐	
Well construction log	Yes ☐ o ☐	
Type of pump		
Pump size (impeller diameter, Horsepower, yield, etc)		
Water Quality Sample Results		
Electrical Conductance of Water		

Obs:

Cond: 495 mS/cm
Temp: 19.5 ºC

TIme: 17:00
Date: 21 Jul 2004

Q=24s → 0.5 l of water

PICTURES: